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WEEKLY May 30–June 5, 2020

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News with implications for life on Mars, the discovery of our five separate appetites, Geordi La Forge, and the world's weirdest plant.

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Covid-19 daily update

The day's coronavirus coverage updated at 6pm BST with news, features and interviews.

newscientist.com/coronavirus-latest

NASA/JPL-CALTECH

Alien oceans Discover the best spots for extraterrestrial life on 4 June

MICHAEL SCHWAB/GETTY IMAGES

Strange plants The remarkable resilience of *Welwitschia mirabilis*

PAULO OLIVEIRA/ALAMY

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A note from the editor

Events are a big part of what *New Scientist* does, offering a chance for you to hear directly from the world's top scientists in the most interesting fields. In March, for obvious reasons, we had to put our in-person live events on hold. So what next?

Virtual events were something we had considered but hadn't had the opportunity to explore in detail. In a spirit of experimentation, then, we launched our first virtual event on 16 April, an open-to-all discussion on coronavirus. Almost 3000 people watched live. Our second event, on black holes, was our first paid-for virtual event. We sold 850 tickets, and people tuned in from every continent except Antarctica to watch. We were delighted by the truly global nature of the occasion.

Since then, we have had a panel discussion on the flood of research around covid-19, and as the magazine went to press we were preparing for a quantum physics event starring Vlatko Vedral. On 4 June, we will be hosting a talk on alien oceans. And – delighted by the interest from so many of you – we are planning many more digital events.

This is a learning experience for us, involving new platforms and challenges, but the feedback so far has been overwhelmingly positive. To find out how to watch an event on catch-up, or explore future ones, visit newscientist.com/events

Emily Wilson
New Scientist editor

We're looking for the best ideas in the world.

The Ryman Prize is an international award aimed at encouraging the best and brightest thinkers in the world to focus on ways to improve the health of older people.

The world's ageing population means that in some parts of the globe – including much of the Western world – the population aged 75+ is set to almost triple in the next 30 years.

The burden of chronic diseases including Alzheimers and diabetes is set to grow at the same time.

In order to stimulate fresh efforts to tackle the problems of old age, we're offering a $250,000 annual prize for the world's best discovery, development, advance or achievement that enhances quality of life for older people.

The Ryman Prize was first awarded in 2015 to Gabi Hollows, co-founder of the Hollows Foundation, for her tireless work to restore sight for millions of older people in the developing world.

World-leading researchers Professor Henry Brodaty and Professor Peter St George-Hyslop won the prize in 2016 and 2017 respectively for their pioneering work into Alzheimer's Disease.

The 2018 Ryman Prize went to inventor Professor Takanori Shibata for his 25 years of research into robotics and artificial intelligence.

The 2019 prize winner was Dr Michael Fehlings, a Canadian neurosurgeon who has dedicated a long career to helping older people suffering from debilitating spinal problems.

If you have a great idea or have achieved something remarkable like Gabi, Henry, Peter, Takanori or Michael we would love to hear from you.

Entries for the 2020 Ryman Prize close at 5pm on Friday, June 26, 2020 (New Zealand time).

Go to www.rymanprize.com for more information

Prime Minister Jacinda Ardern with 2019 Ryman Prize winner Dr Michael Fehlings.

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A new, better normal?

The coronavirus provides a chance to reassess our attitudes to the environment

ALMOST everyone has felt at least some yearning for a return to "normality". The economic, social and mental costs of lockdown have been high, alongside the terrible toll of lives cut short.

Around the world, countries are, quite naturally, assessing how they can allow their citizens to resume some of their former freedoms, and individuals are asking how they can best keep themselves and others safe as restrictions are eased (see page 10). What is clear, however, is that with no immediate prospect of an effective vaccine, the new "normal" won't be the old one.

An important question now is: is that entirely a bad thing, or can something positive be wrung from this grim situation?

Over relatively few decades, a paradigm of unbridled consumption in richer economies, with little regard for longer-term consequences, has established itself as a global aspirational norm. That has taken a shocking toll on our planet, in terms of any environmental measure you choose to consider, be it pollution, biodiversity or, of course, climate change.

> "Covid-19 has given us a glimpse of a world in which systems can be torn up, and ways of life radically altered"

Then came covid-19. Suddenly, once clogged motorways stood empty and the sight of a plane overhead became something worth remarking on.

Pollution and carbon emissions, unsurprisingly, have for now gone down (see page 18) – although we must be realistic that this will have little if any long-term effect on global warming.

The situation hasn't been universally good for nature: poaching, for example, has become easier (page 8).

But covid-19 has given us a glimpse of a world in which systems can be torn up, and ways of life radically altered, when the political will is there.

Many environmentalists now dare to hope that this glimpse of rapid and radical global action could be a catalyst for desperately needed change. As Petteri Taalas, head of the World Meteorological Organization, tells us this week (see page 30), this emergency really could be a turning point in our attitudes towards the looming climate emergency – if we choose to make it happen. ▮

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Fix the Planet

Overwhelmed by climate change? You're not alone

Fortunately, there are reasons for hope in science and technology around the world. Sign up to our monthly climate newsletter and we'll email you a dispatch about an idea, project, person, company or breakthrough that could speed us up on the road to zero emissions.

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Adam Vaughan

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PETER MACDIARMID/SHUTTERSTOCK

Police community support officers patrol Brighton beach on the bank holiday weekend

UK begins to open up

Parts of the UK are set to further lift lockdown restrictions, but a political scandal could put public health at risk, says **Penny Sarchet**

DECLINES in hospital admissions, the number of people in intensive care and deaths in the UK all indicate that the restrictions brought in on 23 March to slow the spread of the coronavirus in the country have helped.

Plans to partially reopen schools and some shops as early as 1 June are being pursued in England, while in Scotland, some restrictions are expected to ease from 28 May. Some restrictions have also been removed in Wales and Northern Ireland in recent weeks. With thousands of new cases still being confirmed in the UK, extensive testing and contact tracing will be needed to prevent a second wave of infection.

According to the latest provisional data published by the UK's Office for National Statistics (ONS), 41,220 deaths involving covid-19 had been registered in England and Wales by 15 May. In the UK, more than a quarter of deaths in the seven-day period ending 15 May involved the disease.

As *New Scientist* went to press, the Johns Hopkins University covid-19 dashboard placed the UK as home to the second-highest number of confirmed covid-19 deaths, behind the US. The UK also had the fourth-highest total of confirmed covid-19 cases, behind the US, Brazil and Russia.

The UK faces a particular challenge in easing its restrictions because, even though the number of new cases is in decline, it remains high. France, for example, reported 115 new coronavirus cases on 24 May, while nine were reported in Australia on 25 May. In the UK, 1625 new cases were reported on 25 May. The ONS estimates that 61,000 new infections a week occurred in England between 4 and 17 May.

"Lockdown is being released very gradually, as has been the case in many other countries," says Linda Bauld, a public health specialist at the University of Edinburgh, UK. "Most of the changes at the moment involve more activity outdoors, where the risk of transmission is low and therefore we wouldn't expect this to result in a rapid rise in cases if social distancing is maintained."

But the scandal surrounding Dominic Cummings, the prime ministerial aide who drove more than 400 kilometres from his London home with his son and ill wife in March, at a time when the UK government was urging the public to "stay home", may put this progress in jeopardy.

"The extent to which people will be willing to continue following the rules has been threatened by the Dominic Cummings case. It sends a clear message to the public that government advice is open to interpretation," says Bauld. This could be seen by some as an invitation to take risks that could go on to cost lives, she says.

Behavioural scientists who have been advising the UK government expressed concerns to *New Scientist* that the Cummings revelations threatened public compliance with the restrictions.

"To encourage a particular behaviour, it's important that people perceive that everybody around them is doing that behaviour. That's why it's vital that we all see and hear how well people are complying," says Val Curtis at the London School of Hygiene & Tropical Medicine, who has participated in the Scientific Pandemic Influenza Group on Behaviours (SPI-B), which advises the UK government on how best to get the public to stick to measures recommended by medical or epidemiological experts. "When attention turns to non-compliers, it effectively gives permission to people to deviate from a social norm," she says.

"I would urge people to continue to maintain physical distancing and the other regulations, for their families, their neighbours and their community," says John Drury at the University of Sussex, UK, who has also participated in SPI-B.

It is unclear whether the large-scale testing and contact tracing infrastructure needed to prevent the number of new cases rising will be ready in time. "We need to get our test, trace, isolate response up and running at scale," says Bauld. "In the absence of a vaccine or effective treatments, in order to avoid a second wave we will need to understand where cases are rising and take swift action to contain local outbreaks." ▮

Wildlife and biodiversity

Conservation in crisis

While lockdowns have allowed some animals to roam more freely, they have also hit vital conservation efforts hard, reports **Michael Marshall**

MINT IMAGES RF/GETTY IMAGES

Before the pandemic, ecotourism funded much conservation work

IN THE midst of the coronavirus pandemic, many of us have become more aware of nature. Conservationist Richard Corlett has spent the past few months in London, where normally he would hear constant noise from buses, aeroplanes and ferries. "They're all gone," says Corlett, who usually works at the Xishuangbanna Tropical Botanical Garden in Yunnan, China. "Birdsong is all I hear in the morning. This is the experience of tens of millions worldwide."

But while coronavirus measures may be good for some species (see "Are any animals benefitting from coronavirus lockdowns?", right), they have also crippled two crucial industries: ecotourism and legal trophy hunting. "That's the two main things that bring money to wildlife conservation," says Marine Drouilly, who works for the Panthera charity in Cape Town, South Africa.

The temporary loss of these industries means there is less money to pay rangers to guard threatened species from poachers, or to fund researchers (*Biological Conservation*, doi.org/ggv5b3). It also means such species are less valuable when alive, which could lead to local exploitation of threatened plants, animals or ecosystems.

As a result, problems are accumulating. "There's no lockdown for rhino poachers or bushmeat traders," says Drouilly. She says the threatened rhinos in Kruger National Park are in serious danger from poaching. Furthermore, there is concern that people who have lost their incomes may resort to bushmeat hunting to support their families.

In the Comoro Islands northwest of Madagascar, turtles are poached as part of a tradition that assigns social status to the men that eat them. In early May, local organisation Oulanga Na Nyamba reported finding the bodies of 28 endangered green turtles on a beach. This followed the cancellation of beach patrols for a month due to coronavirus restrictions. Two poachers were later caught with more than 60 kilograms of turtle meat.

Meanwhile, in the UK, the Royal Society for the Protection of Birds says it has received 56 reports of illegal killings of threatened birds of prey since the UK's lockdown began. The killing of such birds on moors used for recreational grouse shooting is a long-standing problem affecting hen harriers and other species, and many of the recent reported attacks took place on or near grouse lands.

Some conservation organisations have managed to continue their normal operations. The Southern Tanzania Elephant Program works to help people and elephants live alongside each other. Chief executive Trevor Jones says the programme's staff who work closely with local communities are taking precautionary measures, such as wearing masks and reducing the size of meetings, but that they have been able to carry on working. However, the programme only has enough grant money to last a few more months and it is unclear if it will be able to obtain more.

Many other organisations face similar cliff edges. If ecotourism and trophy hunting remain shut down for a year or more, the impact "could be disastrous", says Corlett.

> "If ecotourism and trophy hunting are shut down for a year or more, the impact could be disastrous"

The latest on coronavirus
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Zoos and aquariums have already been hard hit, says Martín Zordan, chief executive of the World Association of Zoos and Aquariums in Barcelona, Spain. "Most of our members, around 95 per cent, had to close their doors to the public," he says. "It's the first time we've seen something like this of this magnitude."

Zordan says no zoos have yet gone bankrupt, and some governments are providing aid to institutions. The UK government has given support to the Zoological Society of London, which runs London Zoo, for example. But if zoos cannot reopen, the situation will only get worse.

The priority is to protect the animals, as zoo populations are key to preserving threatened species, says Zordan. "At the moment, all animals are receiving the care they need," he says.

But if institutions run out of the money needed to care for them, captive animals cannot simply be released into the wild. The last resort is euthanasia. "Hopefully we will not get to that point," says Zordan.

These problems are likely to be reduced in countries that are able to reopen their economies in the coming months. But the biggest impact of the pandemic on conservation may end up being political in nature.

Altered ambition

Before the pandemic, a major conservation summit was due to be held this October in Kunming, China: the 15th Conference of the Parties to the Convention on Biological Diversity (CBD). Corlett describes this as "a one-in-ten-year meeting" that "was going to set the global conservation agenda for the next 10 years". However, the meeting has been postponed indefinitely.

Ten years ago in Aichi, Japan, the CBD set out 20 targets, such as halving the rate of loss of natural habitats, and creating protected areas that span 17 per cent of terrestrial and inland water, and 10 per cent of coastal and marine areas. "We've made progress towards almost all the targets," says Corlett, but none of them has been met, and "in some cases progress has been pretty low".

The initial mood going into this year's planned meeting was mixed, says Corlett. A preliminary draft of an agreement was circulated in January and suggested targets such as expanding protected areas to cover 30 per cent of the world. Corlett says this was "nowhere near ambitious enough" and that many governments were distracted by other issues – even before the covid-19 pandemic. "I just don't think by October people were going to take this seriously enough," he says.

56

illegal killings of birds of prey have been reported in the UK

So will the pandemic divert governments' attention from biodiversity even further, or could it focus it? Conservationists are emphasising that the pandemic is ultimately the result of our over-exploitation of animals: the virus came to us from bats, possibly via the illegal wildlife trade. In response, China has shut down wild animal markets and may permanently ban all trade in wildlife in coming months.

Could more such actions follow? Corlett says he finds himself veering between optimism and pessimism. "We need a global reset and maybe this will occur." ■

Are any animals benefitting from coronavirus lockdowns?

Some of the heart-warming stories about nature thriving during lockdown, like the claim that dolphins had returned to the canals of Venice, aren't true. But others do stand up.

For example, there is evidence that wild bees will benefit from the decline in air pollution, which can disrupt their ability to smell flowers at a distance. And, anecdotally, some wild animals are venturing into cities, including wild cats. "Some people have seen caracals in their garden or crossing their gardens," says Marine Drouilly at the Panthera charity, who is based in South Africa.

The International Bio-Logging Society is organising a global study of data from camera traps and other tracking devices to see if wild animals really are shifting their ranges, but the results may not be available for two years.

We do know, however, that the oceans are quieter and that is likely to be good for wildlife. In Alaska, cruises have been cancelled because of covid-19. "There's been no large vessel traffic, and we're not expecting any until at least late July," says Christine Gabriele at Glacier Bay National Park and Preserve. The only boats on the move are small local ones.

Gabriele is engaged in a multi-decade study of humpback whales in the area. A key element is monitoring how they call amid the underwater noise caused by heavy boat traffic, using a hydrophone anchored to the bottom of the ocean at the mouth of Glacier Bay.

It is early days, but Gabriele says the quieter waters caused by the cruise cancellations may mean the whales can spread out more widely: "They'll be able to communicate with each other over much greater distances than they would be if it was a noisy environment." They may also be able to communicate for longer, using more complex vocalisations.

DAVE FLEETHAM/ZUMA PRESS/GETTY IMAGES

Humpback whales may benefit from reduced noise from boat traffic

Gabriele is hopeful that the quiet will be good for the local humpback whales, whose population has been falling since 2013.

"If it's a productive summer and a quiet summer, that will be a real advantage to this population that's been going through some really tough times," she says. MM

Virus transmission

How to reduce your risk

As countries ease coronavirus lockdowns, **Linda Geddes** looks at what the science says about how to stay as safe as possible

THE coronavirus is still circulating yet many countries are taking steps to relax restrictions. If you have been asked to return to work or send your children back to school, how can you minimise the risk of infection to yourself and your family?

Although there are still many unknowns about the virus, a growing amount of data on how it transmits and survives on surfaces can guide our decisions.

Avoiding infection

You are most likely to catch the SARS-CoV-2 virus by spending a long time near an infected person in an enclosed space. Researchers in Guangzhou, China, examined how the virus was transmitted between 347 people with confirmed infections and the people they had contact with. They found that the risk of the infection being passed on at home or by repeated contact with the same person was approximately 10 times greater than the risk of passing it on in a hospital and 100 times greater than doing so on public transport (medRxiv, doi.org/dwgj).

"The virus spreads more in communal areas with higher numbers of people passing through"

Outside the home, it is difficult to rank the relative risks, because environments vary so widely. However, "what we can say is that SARS-CoV-2 spread tends to be higher in communal areas where there are higher numbers of people passing through, or in areas where there is more physical engagement with the surroundings, for example door handles, desks and computer keyboards", says Seema Jasim at the MRC-University of Glasgow Centre for Virus Research, UK.

The risk also seems to be higher when people are more physically active. Investigations into a cluster of cases in the South Korean city of Cheonan revealed that eight fitness instructors became infected with the virus after attending a 4-hour Zumba workshop. Some of them subsequently passed it on to students during classes which involved high intensity exercise in a small indoor studio (*Emerging Infectious Diseases*, doi.org/ggwpjz).

"The moist, warm atmosphere coupled with turbulent air flow generated by intense physical exercise can cause more dense transmission of isolated droplets," writes the team that conducted the study. However, students attending smaller yoga and pilates classes in the same space didn't become infected.

Regular, thorough handwashing is still advised. It remains unclear how long the virus can survive and remain infectious on surfaces, but this is still thought to be a significant route of transmission.

"If surfaces have been contaminated with droplets from an infected person, there might be sufficient virus to infect a person who touches the surface and subsequently transfers the virus to their mouth, nose, eyes or face," says Margaret Hosie, also at the MRC-University of Glasgow Centre for Virus Research. "However, if they wash their hands thoroughly with soap and warm water for a minimum of 20 seconds, any virus on their hands will be destroyed."

A recent study revealed that handwashing six to 10 times a day is associated with a 36 per cent reduction in the risk of becoming infected with the coronavirus (Wellcome Open Research, doi.org/dwgk).

Because soap dissolves the virus's fatty outer envelope, washing with water but no soap isn't as effective. Alcohol hand rubs work, but are only necessary where there is no access to handwashing facilities, says Hosie.

SALVATORE LAPORTA/KONTROLAB/LIGHTROCKET VIA GETTY IMAGES

Getting around

Many people need or are being asked to travel to work, while in some countries exercising outdoors is permitted. So how can you minimise the risk in these circumstances?

"Whatever you're doing outdoors, a 2-metre distance [from other people] should be enough," says Lena Ciric at University College London. This is based on observations that large, virus-packed droplets from infected people tend to settle within a few metres of their source. "Smaller droplets, carrying fewer virus particles, can travel further but will be dispersed by air currents quickly," says Ciric.

But more research is needed to understand the role of small, aerosol particles in transmitting the virus. A recent study suggested that droplets may be carried as far as 8 metres in clouds of moist, turbulent air, such as those produced by sneezing (*JAMA Insights*, doi.org/ggqtj4). The study didn't, however, test if such clouds could transmit the virus or what would happen to similar clouds in an outdoors setting.

For getting to work, modes of transport that avoid other people, such as walking, cycling or driving in your own car, are the lowest risk. Car sharing may be the next safest option, assuming the driver is only giving lifts to a limited

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Protective plastic screens have been fitted in a cafe in Naples, Italy

number of people. Taxis carry numerous passengers, so there is a risk of contracting the virus from surfaces like seats and door handles, or from the driver speaking, coughing or sneezing.

If these options aren't available, that leaves public transport. People who travel on buses or trams during the winter flu season may be approximately six times more likely to develop a respiratory infection than those who don't use public transport.

If you do have to use it, there are things you can do to reduce your risk. The amount of time you spend near other transport users matters, says Anders Johansson at the University of Bristol, UK, who has modelled disease transmission in crowds and on the London Underground.

36%

reduction in risk of infection if you wash your hands frequently

Besides trying to avoid the busiest stations and travelling times, it is worth considering the amount of time you spend navigating stations. Those with long underground passages – especially if they involve encountering people walking in the opposite direction – are best given a wide berth, and changing trains is also best avoided. These "usually mean you spend a longer time in the station, and are mixed together with people coming from various different parts of the city, if not the country", says Johansson.

The risk of exposure may be slightly lower on buses, trains and trams with outdoor platforms, but once inside the vehicle, infection risk depends on how well passengers can spread themselves out and how many are getting on and off. "If you stand next to the door of the bus, there will be lots of people passing by you at close distance," says Anders.

Simulation of respiratory disease transmission on aircraft has found that moving around the cabin increases a person's risk of encountering an infected passenger, while those seated by windows tend to have the lowest contact with other people.

When travelling, continue to be mindful of surfaces. The aircraft transmission study identified tray tables, seat belts and lavatory handles as high-risk objects, but hand or grab rails, payment terminals and protective plastic screens can also harbour viruses.

Countries vary in their advice on face coverings when getting about. So far, the evidence suggests there may be a small benefit to wearing some kind of face covering, as these seem to lower the extent to which sick people spread the virus. In addition, face coverings may help protect vulnerable people who temporarily enter high-risk places like hospitals – but using medical masks can deprive healthcare workers of protective equipment.

Risks at work

There are reasons to be nervous about indoor workspaces. A study in Japan that followed up the contacts of 110 infected people concluded that the chance of catching the coronavirus in a closed environment is more than 18 times greater than in an open-air environment. Super-spreading events, where an infected individual passes the coronavirus onto many others, were also more likely to occur indoors (medRxiv, doi.org/dwgn).

Some indoor environments may be riskier than others. During the covid-19 outbreak in Wuhan, China, researchers sampled air from various locations in two hospitals. Viral RNA was detected in an intensive care unit, in staff changing areas and in a small, unventilated toilet (*Nature*, doi.org/ggtgng). Hosie says poorly ventilated areas are likely to have a higher risk of infection. "Good ventilation means changing the air within the space regularly, not just cooling and recirculating the same air," says Ciric.

REUTERS/DINUKA LIYANAWATTE

Social distancing inside an elevator in the World Trade Center, Sri Lanka

Another study from Wuhan revealed desktops, computer keyboards, doorknobs and hand sanitiser dispensers to be the most contaminated surfaces within hospitals. More virus was detected on these than on gloves, eye protection and face shields used in the hospitals (medRxiv, doi.org/ggqtpr). Regularly disinfecting high-contact surfaces and shared objects is therefore essential – as is washing your hands after touching them.

Workplace schedules can also be tweaked to reduce the chances of people mixing. "Maybe everyone doesn't need to arrive or go for their lunch break at the same time," says Johansson. "You might not think that staggering the time when people start work is a big deal, but in the case of a big warehouse it could make a massive difference because you wouldn't necessarily have a massive crowd waiting outside for when the door opens."

Clear plastic screens may be useful for workers whose roles mean they encounter large numbers of people and make social distancing difficult, such as supermarket checkout staff, pharmacists or medical receptionists. "In these settings, they would act as a physical barrier to airborne droplets," says Jasim.

But how effective they are depends on their size and how well they are fitted. "They can also become a risk if they are not

›

regularly cleaned," says Ciric. Face coverings may also benefit workers who need to interact with many people.

Returning to school

From the data published so far, children seem less likely to acquire the infection than adults, and when they do, they are less likely to develop serious symptoms. Although a small minority do become seriously ill – including with a newly identified inflammatory syndrome – this is also true of many other viral illnesses.

"In a pandemic, where so many people are being infected without any prior immunity, it is perhaps no surprise that some people are getting inflammation during the later stages," says Saul Faust at the University of Southampton, UK. "We do need to understand it better. But what is clear is that for children, it is a very small number and they are almost all getting better, although some do need hospital treatment."

There is also little evidence of schools and nurseries being major breeding grounds for infection, so far – although this is difficult to assess because many countries closed their schools relatively early in the pandemic.

Some new reassurance comes from a report by the Children's Commissioner for England, whose team has interviewed the managers of 44 nurseries that are attached to NHS hospitals and have remained open. Three have reported a confirmed case of covid-19 in a child and eight have reported a suspected case, but they have found no evidence of child-to-child transmission within the nurseries.

DAMIEN MEYER/AFP VIA GETTY IMAGES

A teacher wears a protective mask in Bruz, France

And although 19 nurseries reported a confirmed or suspected case of covid-19 among their staff, in 10 cases the manager stated that it wasn't caught from the nursery, while in the remaining cases the source was unclear. Similarly, in New South Wales, Australia, just two out of 735 students contracted the virus after attending schools where there were nine infected children and nine infected adults.

On the other hand, opening schools may prompt an increase in cases among the general population. Denmark, which reopened its primary schools on 15 April, did report an increase in the R number – the average number of people each case goes on to infect – from 0.6 to 0.9 in the following two weeks, but this has since dropped again.

Even if children don't seem to spread the virus as much as some people had feared, for some families, the risks of sending their children back to school or nursery will outweigh the benefits. "Of course, you have to consider each family's circumstances, and the risk changes if you have a mum or dad who has cancer, or a grandfather who is living in the same house who has hypertension, or the only after-school childcare available to you is grandma, who has cancer," says Faust. "But if it's your child's health you're most worried about, the risk to them appears low."

However, waiting a while longer could reduce this risk even more. On 22 May, a group of independent scientists announced that modelling suggests that delaying plans to reopen schools in the UK on 1 June by two weeks would halve the risk to children, while waiting until September could reduce the risk even further.

Meeting up with friends and family

Evidence suggests that infection in the home, and between family members, is a significant source of viral transmission, and visiting people at home is still not allowed in many countries. Because transmission risk is probably much lower in the open air and can be reduced by maintaining a distance of 2 metres, it is probably safer to meet with people from outside your household in uncrowded outdoor spaces.

But what if you and a friend have both been strictly self-isolating? Would it then be safe to visit each other? Generally, you would expect any symptoms of an infection to have developed, and viral shedding to have largely ceased, 14 days after catching the virus. This may also be true of asymptomatic cases. "In both instances, at the end of the 14-day period they would be considered non-infectious," says David Heymann at the London School of Hygiene & Tropical Medicine.

This may suggest that, if you have remained at home for the past 14 days and had no external contact, you are unlikely to be carrying the virus.

However, there have been reports of the virus persisting in the body for longer than two weeks. An analysis by US researchers calculated that 97.5 per cent of people who develop covid-19 symptoms do so within 11.5 days of exposure, but they estimated that for every 10,000 individuals quarantined for 14 days, about 101 of them would develop symptoms after this period (*Annals of Internal Medicine*, doi.org/dph3). A study in China reported incubation periods ranging from 0 to 33 days, and suggested an 18 or 21-day quarantine would catch far more cases (medRxiv, doi.org/dwgp).

For this reason, people should remain cautious about visiting other people, especially if they know they have been infected or have encountered other infected people. Additionally, if either of you are in groups deemed vulnerable to covid-19, Heymann suggests you both wear masks as an extra precaution when getting together. ▮

PLEASE NOTE

We urge you to keep up to date with and follow your local guidelines. When *New Scientist* went to press, the guidelines for England, for example, were that anyone who is able to work from home should continue to do so, and that social visits should be limited to outdoor meetings with only one person at a time, at least 2 metres apart. Face coverings are advised in enclosed public spaces.

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Analysis Space exploration

Lunar laws of the land The US government is starting to lay down the groundwork for international diplomacy on the moon, says **Leah Crane**

ON 15 May, NASA administrator Jim Bridenstine released a set of principles that will govern the Artemis Accords, a series of agreements the US wants to make with other countries to foster cooperation in moon exploration. The accords are named after NASA's Artemis programme, the US initiative to explore the moon, with a planned launch of astronauts to the lunar surface in 2024.

At the moment, there is little practical international law governing lunar activities. The Outer Space Treaty of 1967 deals with general space exploration, while the Moon Agreement of 1984 states that "the moon and its natural resources are the common heritage of all mankind", prohibiting the ownership of any part of the moon or any resources from it.

That sounds pretty conclusive, but no nation capable of human space flight has signed the Moon Agreement, effectively rendering it moot. Last month, US president Donald Trump issued an executive order to support moon mining and take advantage of the natural resources of space.

The Artemis Accords take the same tack. Although protecting historic locations like the Apollo landing sites, they encourage mining in other areas. They also promote transparency and communication between nations, requiring signatories to share their lunar plans, register any spacecraft sent to orbit or land on the moon and release scientific data to the public.

Transparency might be a stumbling block for potential parties to the accords, says space consultant Laura Forczyk. "I really don't know how much countries are going to be willing to share some of their more delicate, sensitive information," she says. "But hopefully this is the kind of olive branch that says, 'Hey, we're willing to do this if you are'."

NASA plans to land astronauts on the moon in 2024

NASA

The rest of the stipulations of the Artemis Accords are about safety: nations will be able to set "safety zones" to protect their activities on the moon, they will have to work to mitigate the effects of debris in orbit around the moon and they will agree to provide emergency assistance to any astronauts in distress.

"These are agreements to be a good citizen in space," says space lawyer Laura Montgomery. "You don't want anybody landing on your lunar habitat and you also don't want rocket plumes kicking up dust and rocks and breaking windows."

Rather than attempting to put together an international treaty, which could be difficult to negotiate before NASA's next crewed launch to the moon, the US will sign accords with individual countries.

Montgomery says this may make the agreements more functional than a blanket treaty where all nations have to ratify the same document. "If you have a robot arm and I have a habitat housing astronauts, we don't need the same information in that agreement," she says.

As international agreements, the Artemis Accords won't apply directly to companies – if they are to follow the rules laid out in the accords, it will have to be through government contracts or the national laws where they operate. For now, most space-flight firms are reliant on government contracts, so it shouldn't be a problem, says Forczyk. Once the agreements are in place, they will represent a step towards having a law of the land on the moon. ▮

Vaccines

HPV vaccine linked to fewer premature births in Australia

WIDESPREAD HPV vaccination looks to have prevented thousands of premature births in Australia.

Women who have had HPV, the human papillomavirus that causes genital warts and cervical cancer, are at greater risk of having premature babies. This may be because the treatment for high-risk HPV infections involves removing affected cells from the cervix, which can prevent cancer but may sometimes affect the mechanical strength of the cervix.

Australia was one of the first countries to introduce a national HPV vaccination programme in 2007, offering free school-based vaccines to girls aged 12 to 13 and a catch-up programme for women aged between 18 and 26.

About 80 per cent of eligible Australian girls have since received the vaccine annually, leading to a sharp decline in HPV infections, genital warts and precancerous cervical lesions. Now, research by Karen Canfell at the Cancer Council NSW in Australia and her colleagues suggests it has also cut rates of premature births.

Premature births have been steadily climbing in Australia for the past two decades, in line with what has happened in other developed economies, possibly due to reasons such as people having children later in life or IVF conceptions becoming more common.

But using Australian birth data from 2000 to 2015, Canfell's team has found that women from vaccinated cohorts had 3 per cent fewer premature babies than those from unvaccinated cohorts after adjusting for the age of women and the years they gave birth (*The Journal of Infectious Diseases*, doi.org/dwfn).

"The vaccination programme has probably prevented at least 2000 premature births"

The vaccination programme has probably prevented at least 2000 premature births in Australia since it began, says Canfell, although the study couldn't account for some other factors, such as changes in smoking habits or other behaviours. ▮

Alice Klein

Solar system

Distant object is being hugged by a large moon

Jonathan O'Callaghan

AN OBJECT on the outer edges of the solar system may have a large moon orbiting it at an unusually close distance. The find could help explain how such binary objects evolved.

José-Luis Ortiz at the Institute of Astrophysics of Andalusia in Spain and his team observed the object, known as 2002 TC302, in January 2018, when it eclipsed a distant star, casting a shadow on Earth and allowing its properties to be studied.

The researchers deduced that the object was likely to be about 500 kilometres across. But they also found something unusual: what appears to be a large moon about 200 kilometres across orbiting less than 2000 kilometres from it (arxiv.org/abs/2005.08881).

This distance is around five times the height of the International Space Station above Earth, meaning the moon would loom large in 2002 TC302's sky.

The object is one of many trans-Neptunian objects (TNOs), and orbits the sun at an average distance of 55 times the distance between Earth and the sun. Other TNO satellites are normally much further from their parent body, says Ortiz.

Objects made of two bodies that touch each another, known as contact binaries, may be abundant in the solar system – one example is the two-lobed object Arrokoth, which was visited by NASA's New Horizons spacecraft in early 2019.

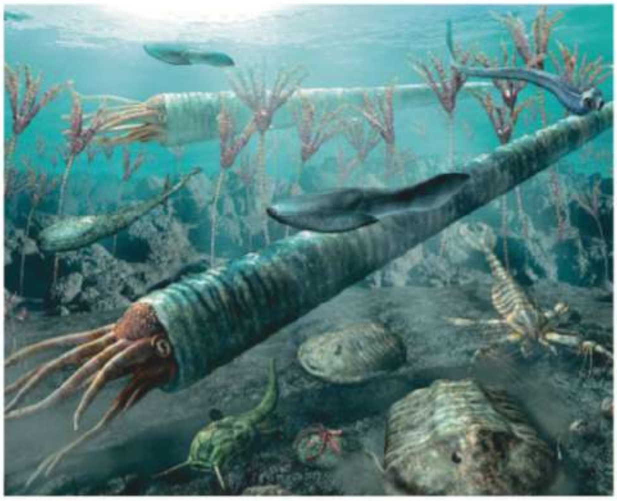
But finding a non-touching binary like 2002 TC302 and its moon orbiting so closely would be a first, providing some useful information about these dual systems.

It may suggest a lot of TNOs were born with a large amount of angular momentum, spinning themselves into pieces to create satellites. Close satellites could also cause large tidal interactions with the parent body, producing wobbles in the orbit that could reveal details about both bodies' interiors, says Ortiz.

Geology

All five mass extinctions are now linked to global warming

Colin Barras



MASATO HATTORI/SCIENCE PHOTO LIBRARY

Ancient marine life may have been wiped out by volcanic activity

THE second-most severe mass extinction in Earth's history may have been triggered by global warming. The discovery means that, for the first time, all of the largest known extinctions can be linked to a rapid rise in the planet's temperature.

"It completes the jigsaw puzzle in many ways," says Andrew Kerr at Cardiff University, UK. Geologists recognise five points in time when huge numbers of species were wiped out, although recent research suggests at least one of these might have been too slow to be a mass extinction.

But the second-most severe of these five extinctions, the late Ordovician event about 445 million years ago, has always seemed different. The others coincided with epic volcanic activity that smothered millions of square kilometres with lava to create what is called a large igneous province.

In each case, the volcanic activity triggered global warming that is likely to have contributed to extinction. In contrast, the consensus had been that the late Ordovician extinction was prompted in part by global cooling.

David Bond at the University of Hull, UK, thinks it wasn't so different after all. With his colleague Stephen Grasby at the Geological Survey of Canada, Bond took samples from a site in Scotland where rocks that formed on the late Ordovician sea floor are well-preserved. They found a spike in the level of mercury in rocks that formed just before and during the extinction (*Geology*, doi.org/dwd3).

445

million years ago, the late Ordovician extinction occurred

"Large volcanic eruptions put anomalously high levels of mercury into the atmosphere," says Bond. There seems to have been large-scale volcanic activity during this period after all.

"It's a great boon to the mass extinction story, which now links all past mass extinctions to large igneous province volcanism," says Gerta Keller at Princeton University.

Bond thinks this might have led to global warming that heated the oceans, reducing their ability to hold dissolved oxygen and suffocating marine life. This would explain why the Scottish rocks also contained high levels of uranium, as this element precipitates out of seawater and accumulates on the sea floor when oceans lose their oxygen.

Confusingly, there was global cooling at the time too. Bond says it looks as if this only began after the volcanism and global warming had triggered the mass extinction. "Everything lines up nicely," he says, although he accepts that the new extinction scenario will be controversial.

Charles Mitchell of the University at Buffalo, New York, remains to be convinced. He says the global cooling and a severe glaciation may well have begun before, and contributed to, the extinction. But he says volcanic activity and global warming could have played a part in the latter stages of the extinction. "You need a way to end the glaciation, and global warming from a large igneous province could do that," he says.

Kerr is more enthusiastic. He has long argued that volcanic activity and associated effects such as global warming are the key drivers of mass extinctions.

Keller says the finding means there might be a new odd one out among mass extinctions: the one we may currently be in is also due to warming, but the carbon dioxide responsible was produced by us, not volcanoes.

New Scientist
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Leah Crane

Animals

Bees cause leaf damage to trigger early flowering and pollination

Alice Klein

HUNGRY bumblebees can coax plants into flowering and making pollen up to a month earlier than usual by punching holes in their leaves.

Bees normally stop hibernating in early spring to feast on the pollen of newly blooming flowers. However, they sometimes emerge too early when plants are still flowerless and devoid of pollen, which means the bees starve.

Fortunately, bumblebees have a trick up their sleeves. Consuelo De Moraes at ETH Zurich in Switzerland and her colleagues discovered that worker bumblebees can make plants flower earlier than normal by using their mouthparts to pierce small holes in leaves.

In a series of laboratory and outdoor experiments, the researchers found that buff-tailed bumblebees (*Bombus terrestris*) were more likely to pierce holes in the leaves of tomato plants and black mustard plants when deprived of food. The leaf damage caused the tomato plants to flower 30 days earlier than usual and the black mustard plants 16 days earlier (*Science*, doi.org/dwf5).

It is still a mystery how the leaf damage promotes early blooming. Previous studies have found that plants sometimes speed up their flowering in response to stressors like intense light and drought.

When the researchers punched holes in the plant leaves themselves, this didn't induce early flowering. This suggests that bees may provide additional cues that encourage it, like injecting chemicals from their saliva into the leaves when they pierce them.

"Climate change is making spring conditions less predictable, which could disrupt the timing of the relationship between bees and flowers," says Mark Mescher, also at ETH Zurich. Manipulating flowering times may help bumblebees adapt to climate change, he says. ▮

HANNIER PULIDO, ETH ZURICH

Bumblebees cut plant leaves to avoid starving if they end hibernation early

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Health

Speedometer blood test could show how fast you are ageing

AGE affects us all eventually, but a lucky few seem to stave off the effects of ageing for longer. A new blood test may help us understand why.

As well as telling us how fast we are ageing, the test can also predict whether a person is more likely to develop a chronic disease or die in the near future. It is an update on epigenetic clocks, tests that estimate a person's biological age based on markers thought to control the way genes are expressed.

"It's like a speedometer – it tells you how fast you're going, in contrast to clocks, which tell you how far you've come," says Daniel Belsky at Columbia University in New York. This means the new test is "a more immediate measure of the ageing rate", he says.

Epigenetic clocks often compare chemical tags on DNA that are markers of gene expression in people of different ages. But these may differ for reasons other than ageing, says Belsky. For example, older people might have had poorer diets or have been exposed to more pollutants and pathogens early in life, he says.

To develop the "pace of ageing" test, Belsky and his colleagues followed 954 people and tracked changes in 18 markers of health. These included indicators of participants' heart, liver, lung and kidney function, as well as their waist-to-hip ratio, blood lipids and markers of inflammation. Each volunteer was assessed at ages 26, 32, 38 and 45.

The researchers used all this to get an idea of the average change in participants' health as they aged and to measure how each person aged biologically. They then used this information to create a single blood test that measures chemical tags on DNA indicating changes in the 18 health markers.

To check whether the test could predict how quickly a person ages, the researchers compared the participants' scores at age 38 with their physical and cognitive health seven years later, when, at age 45, the volunteers took tests of their balance, coordination and cognition and were scored based on how old they looked. "In nearly every case, people whose DNA [markers] suggested they were ageing faster were showing these emerging deficits in function," says Belsky (*eLife*, doi.org/ggt6pr).

"The test is like a speedometer. It tells you how fast you're going, not just how far you've come"

Belsky's team also applied the test to a study that has tracked the health of a group of men, now in their 70s, since the 1960s. The test predicted who would develop worse health and who was likely to die in the subsequent seven years. During this period, "people with a faster [pace of ageing] at baseline were at increased risk to develop a new chronic disease or to die", says Belsky.

The new test represents "the best we can do" to measure ageing, says Sara Hägg at the Karolinska Institute in Solna, Sweden. But a lot more data will be needed before it can be used in clinical settings, says Belsky. As the test is based on people of European ancestry living in New Zealand, it will also need to be trialled in other populations, says Paul Yousefi at the University of Bristol, UK. ▮

Jessica Hamzelou

Human origins

Earliest known Native American relative

A MAN who lived in Siberia about 14,000 years ago is the earliest known person in the world to have the mix of genes seen in people with Native American ancestry.

He Yu at the Max Planck Institute for the Science of Human History in Jena, Germany, and her colleagues dated a man's fossilised tooth, found near Lake Baikal in Siberia, to about 14,000 years ago.

DNA from the tooth revealed that the man had the specific mixture of ancient north Eurasian and north-east Asian ancestry often present in Native American peoples (*Cell*, doi.org/dwdn).

The earliest previously known individual with such ancestry lived about 11,500 years ago.

The results add to growing evidence that the Americas were populated by people from north-east Asia. **Layal Liverpool**

MIGUEL MORENATTI/AP/SHUTTERSTOCK

Biodiversity

Spy satellites reveal decline in marmots

IMAGES taken by cold war spy satellites have unveiled a long-term decline in marmots in Kazakhstan over the past 50 years.

Catalina Munteanu at Humboldt University of Berlin, Germany, and her colleagues analysed satellite images of Kazakhstan taken between 1968 and 1969 by US satellites spying on the Soviet Union. By comparing them with satellite pictures taken between 1999 and 2017, the team found that the number of marmot burrows within a 60,000 square kilometre area had fallen by 14 per cent over that time (*Proceedings of the Royal Society B*, doi.org/dwdf).

Much of the decline seems to be due to the expansion of farming, says Munteanu.

Marmots are a key part of the ecosystem, so changes in their numbers can reflect changes in overall biodiversity. **LL**

Climate change

Coronavirus set to cause huge carbon emissions fall

GLOBAL carbon emissions are likely to see their steepest fall this year since the second world war, but it won't stop climate change.

The first peer-reviewed analysis of the pandemic's impact on emissions predicts they will fall between 4.2 and 7.5 per cent on last year. A rise of around 1 per cent had been expected for 2020.

"In terms of a relative drop, you'd have to go back to the first half of the last century, around WWII," says Glen Peters at the Center for International Climate and Environmental Research in Norway.

Analysing the data up to 7 April, Peters and his colleagues found that lockdown restrictions had cut daily emissions by 17 per cent versus the daily average for 2019. This takes the world back to 2006 levels.

The reductions have been fairly uniform globally, with a drop of 1048 million tonnes of carbon dioxide in the first four months of the year. Peters and his colleagues expect an annual fall of 1524 MtCO_2 if pre-pandemic conditions return by mid-June, or 2729 MtCO_2 if some restrictions are in place until the year's end (*Nature Climate Change*, doi.org/ggwr9w).

However, the team says the drop will make little dent in future global warming. Peters calculates that a 5 per cent drop would be equivalent to 0.001°C less warming, but the world is on course for at least 3°C of warming. The UK Met Office says that atmospheric CO_2 levels will still be the highest in 2 million years.

A report last year found that emissions must fall by 7.6 per cent every year this decade to meet the Paris Agreement's goal of checking warming at 1.5°C. **Adam Vaughan**

For more on coronavirus and climate change, see page 30

Really brief

NRAO/AUI/NSF, S.DAGNELLO

Oldest galaxy that looks like our own

A galaxy that formed 1.5 billion years after the big bang is smoother than expected, which is evidence for a novel, speedy galaxy formation. Like the Milky Way, it is shaped like a disc.

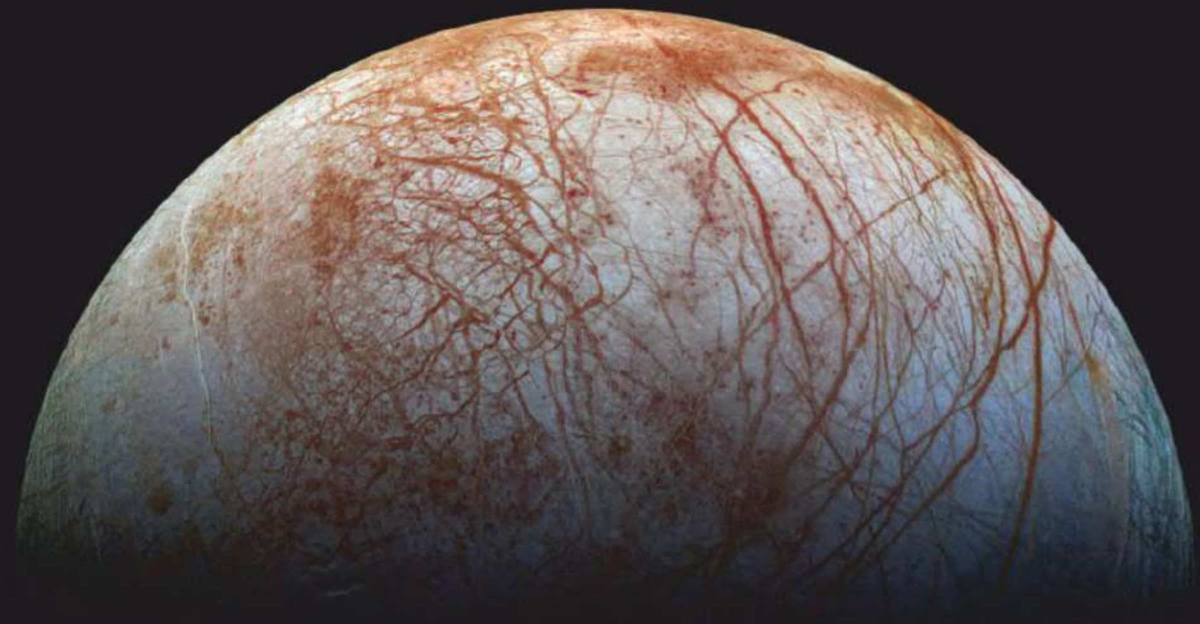
Unlike early galaxies that coalesced from clumped-up hot gas, the Wolfe disc probably formed from smooth flows of cold gas (*Nature*, doi.org/dwcr).

Algae bloom as Antarctic melts

The first large survey of algae growing in Antarctica has found blooms dotted across the continent. At the height of summer, they cover up to 1.9 square kilometres of snow and may spread as the climate warms (*Nature Communications*, doi.org/dwbv).

Artificial eye seems like the real deal

A team of researchers has developed a spherical visual sensor that mimics the structure of the human eye. The artificial eye is 2 centimetres in diameter, and its hollow centre is filled with a conductive fluid. It contains a lens to focus light and a hemispherical retina (*Nature*, doi.org/dwc2).



4 June 2020 6pm BST/1pm EDT

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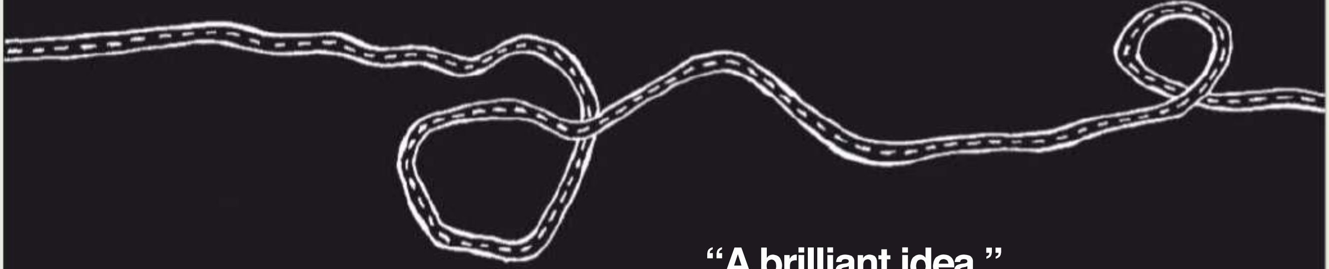

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Views

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A TV satire about the much-maligned US Space Force gets ready to launch p24

Don't miss
Everything you always wanted to know about our feathered friends p25

Aperture
Witness the night sky over Chile as you've never seen it before p28

Columnist

The battle of the bog

A victory for conservation against the odds is a sign that attitudes may finally be changing for the better, says **Graham Lawton**

Graham Lawton is a staff writer at *New Scientist* and author of *This Book Could Save Your Life*. You can follow him @grahamlawton

AS LOCKDOWNS gradually ease across the world, I find myself in a growing state of anxiety. As you may have heard, this pandemic presents a historic opportunity to reinvent our world along more sustainable lines. I agree – but am gripped by fear that we will blow it.

Happily, some positive action has been taken. For example, the mayor of London, Sadiq Khan, announced plans to close much of the city centre to private vehicles, creating one of the world's largest car-free urban areas. Other cities have made similar moves.

But I can't imagine this will go down without a fight, and elsewhere I read that the backlash against a green recovery is under way. US Republicans, for example, are reportedly developing lines of attack that paint the pandemic response – with its mass unemployment and vast rise in public expenditure – as a foretaste of the pain to be visited on people by pro-environmental policies.

Call me a cynic, but if I had to put money on who will win, I'd bet on the right. I am soothing myself with a story that I think shows a better, greener world is possible.

It is about a small nature reserve just outside York, the UK city where I grew up. Askham Bog is one of the last surviving scraps of fenland in a now intensively farmed landscape. Despite its small size – just 44 hectares – it is one of the most ecologically diverse habitats in northern England and is designated as a site of special scientific interest. It has also been under threat for years. York has an acute shortage of housing, and in the early 2010s, the city council identified land just north of the bog as being possibly suitable for development.

In 2018, developer Barwood Land filed an application to build 516 houses on the site. But in 2019, the city council unanimously rejected the planning application on various grounds, including environmental ones.

"Bog supporters feared the worst, as property development usually trumps the environment"

Barwood appealed, triggering a local public inquiry. That meant lawyers, weeks of adversarial hearings and, ultimately, a decision by the secretary of state for housing, communities and local government, Robert Jenrick.

I have to declare a personal interest. My father, a retired ecologist, is president of the Yorkshire Wildlife Trust, which manages Askham Bog and which led the fight against the housing.

It was classic David vs Goliath stuff. The developer retained the services of a formidable QC; the Yorkshire Wildlife Trust crowdfunded a war chest from concerned locals. The developer wasn't oblivious to the ecology, dazzling the inquiry with the results of environmental impact assessments and plans for a protected zone it argued would boost overall biodiversity.

Yorkshire Wildlife Trust responded with some pretty heavy duty ecology. It argued that building on the site would probably damage the bog, and that while the protected zone may increase biodiversity, the incoming species would be aliens.

In November, both sides retired to await what bog supporters feared was a foregone conclusion. Property development usually trumps the environment.

Then the world changed. Two weeks ago, Jenrick wrote to both sides informing them of his decision to uphold the council's 2019 verdict.

The ruling makes it clear it was a close-run thing, but what tilted the scales of justice was the threat to the bog and the "deterioration of irreplaceable fenland habitat". That is all the more remarkable given ecologists couldn't say for sure the bog would be damaged, only that it was "probable".

In a world where we have become used to expertise being trashed, scientific uncertainty being seen as a weakness and the natural world viewed as merely undeveloped resources, this ruling feels like a landmark. Yes, it is just one small bog in the north of England, but its name deserves to be sung across the land. ■

Graham's week

What I'm reading
Underground: A human history of the worlds beneath our feet – *a dark but scintillating account of writer Will Hunt's subterranean excursions*

What I'm watching
Celebrity SAS: Who dares wins. *Grippingly daft*

What I'm working on
Preventing future pandemics

This column appears monthly. Up next week: Annalee Newitz

Editor's pick

Armchair science may lead us to a better place

Leader, 9 May

From Bruce Hamm, London, UK

In your leader, you write: "Non-scientists have many roles to play in defeating the virus, but becoming armchair scientists isn't one of them." You are right that there is a huge problem with people who are unwilling to be led by scientists and the scientific method.

The turn to science by vast numbers of people in the face of the tremendous harm wrought by this pandemic does indeed pose real dangers – but it also opens up great opportunities. Rather than dumping cold water on people's enthusiasm, we need to encourage this in a way that builds an appreciation for science, including the scientifically grounded procedures for determining truth, such as the peer-review process and so on.

A population of true armchair scientists who were willing to look at the world more scientifically and be led by science, rather than getting caught up in all kinds of wacky 5G or anti-vax conspiracies and superstitions, would be a boon.

From Adam Keelan, London, UK

A lack of transparency from the UK government, as shown by its communication strategy, has probably provided more fuel for speculation in this country than any number of pre-publication papers or amount of raw data. As your leader points out, a deluge of poor information has helped make a bad situation worse. But some of it may be coming from Whitehall.

We must prepare for the next big global threat

2 May, p 7

From Harry Butterworth, Landkey, Devon, UK

The long-term lesson of our current predicament is that pandemics do happen, and when they do, many people can be hurt.

I don't expect to see another pandemic – I am 80 – but there is a real chance that my grandchildren will. There is a lot of scientific data building rapidly, and we need a globally agreed plan to deal with the next crisis based on this. As soon as this pandemic is fully under control, we should be looking at the lessons we can learn so a strategy can be agreed on.

From Javier Martin-Torres, Aberdeen, UK

The spread and death toll of covid-19 has made us conscious that we are all connected, as well as of how fragile life, human societies and economies are.

The latent possibility of a viral pandemic wasn't a total surprise, but it isn't the only such enemy. What about a solar flare killing our telecommunication satellites, for example? What are the other latent risks out there?

We should seriously evaluate what other major threats of this sort may be waiting to emerge. Researchers should take the lead and join interdisciplinary efforts to ensure we are prepared.

Other risks in a push for herd immunity?

11 April, p 10

From Robert Maier, Penicuik, Midlothian, UK

I wonder whether there is a serious and overlooked aspect of any drive to achieve herd immunity to the coronavirus in order to end the need for lockdowns.

Attaining herd immunity, if this is even possible, would require a significant proportion of the population to become infected and develop antibodies.

However, the broad distribution of cases may also serve as a breeding ground for new mutations of the virus. The more people who are infected, the higher the probability of new strains of the virus emerging.

If the pool of infected people is kept low, viral mutations, including those resulting in even more dangerous forms of the virus, might be avoided.

Take a lesson from nature's defences

2 May, p 36

From Conrad Jones, Cynwyl Elfed, Carmarthenshire, UK

Your piece on how the turtle got its shell was a fascinating insight into the jigsaw that is palaeontology, especially bearing in mind there are so very few pieces to put together to tell the story of the course of evolution. But what particularly grabbed my attention was the side panel on how zebras got their stripes.

As it appears that this pattern gives them the upper hand by deterring horseflies, why is there no clothing for humans to give us the same protection?

Never mind army-type camouflage for the great outdoors, how about zebra stripes to do something a bit more useful? You never know, it may even help against one scourge of summer tourism in the Scottish Highlands: the midge.

We've been on the trail of dark matter for a long time

16 May, p 30

From Larry Stoter, The North, Monmouthshire, UK

I would say that missing mass and dark matter were elephants in the room of astronomy and cosmology from rather earlier than the 1980s.

It is claimed that as early as 1884, Lord Kelvin suggested that the observed dynamics of the Milky Way didn't seem to match the amount of matter observed, well before other galaxies were even discovered.

The missing mass problem was explored in more detail in the 1920s and 1930s by several astronomers – Jacobus Kapteyn, Jan Oort and Fritz Zwicky, among others – when it became clear that a discrepancy existed between the observable mass of galaxies and their dynamics.

It is more the case that in the 1980s, the elephants grew too big to ignore any longer.

Bring it on: mathematics versus philosophy

2 May, p 40

From Sam Edge, Ringwood, Hampshire, UK

Your article on consciousness raises the tantalising prospect that the validity of ideas put forward to explain it could become amenable to practical mathematical analysis. This is encouraging.

As usual, though, some philosophers have rolled out the argument that the tools of mathematics and empiricism are insufficient to explain subjective experience.

They miss the point. All observation is inherently subjective. This doesn't stop us formulating explanations for phenomena, it just requires a rigorous approach that ultimately rests on predictive power and repeatability.

I have severe red-green colour blindness, so I perceive a rainbow differently from most people, but that doesn't stop us from agreeing that the mathematics of optics explains the phenomenon very well.

I'm not saying that consciousness isn't a tough nut to crack – it isn't called the hard problem for nothing – but arguing that we need new tools without explaining why or suggesting what they might be isn't contributing to the field. Philosophers have been doing this for thousands of years without progressing an inch.

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Welcome to our Signal Boost project. In these difficult times, we are offering charitable organisations the chance to take out a page in *New Scientist*, free of charge, so that they can get their message out to a global audience. Today, a message from **Alzheimer's Research UK**

Alzheimer's Research UK | Make breakthroughs possible

Can you help Alzheimer's Research UK to make breakthroughs in dementia?

Almost every walk of life has been impacted by COVID-19. We know that these are difficult times for everyone, and our thoughts are with all of those who have been directly affected and with the health and care workers who are doing so much to help at this time.

Everyone at Alzheimer's Research UK is acutely aware of the effect the outbreak is having on people with dementia and their families, exacerbating an already unprecedented situation.

Like so many organisations, charities and medical research are also feeling the impact of these difficult times. Social distancing measures mean that many labs have had to temporarily close their doors and economic uncertainty is threatening vital funding for research.

Dementia researchers have been innovating new ways of working to continue to drive scientific progress, but we need to get research programmes back up to speed quickly, as soon as it is safe to do so.

NOW IS THE TIME

It is a critical time in dementia research as scientists work to capitalise on the leaps in understanding over recent years and translate these developments into ways to help the 200,000 people in the UK who develop dementia every year.

Without effective treatments, one in three people born this year will die with dementia. Today, there are no dementia survivors. But research can change this.

At Alzheimer's Research UK our vision is a world free from the fear, harm and heartbreak of dementia. We're developing groundbreaking initiatives to fund the scientists, equipment and ideas that will make life-changing breakthroughs possible. With your support, we're working across four key areas of action to

- Understand the diseases that cause dementia
- Diagnose people earlier and more accurately
- Reduce risk, backed by the latest evidence
- Treat dementia effectively.

And we're making progress. But the months ahead will not be easy. Now more than ever, dementia research needs our backing and your support.

Alzheimer's Research UK is continuing to work for all those living with dementia. If you can, donate today to change lives. Visit https://alzres.uk/donate-ns

Do you need your signal boosted?

If you are a charitable organisation working in science, medicine, technology, education or conservation, and would like to find out more about this project contact Chris Martin on chris.martin@newscientist.com

Boots on the moon

The US Space Force has provided a lot of laughs since its inception. A TV satire about it is almost as comical as the original, says **Simon Ings**

TV

Space Force

Greg Daniels and Steve Carell

On Netflix from 29 May

AS RECRUITMENT ads go, the video released to Twitter on 6 May was genuinely engaging. Young people stared off into the Milky Way as rockets of indeterminate scale rolled out of unmarked hangers. "Some people look to the stars and ask, 'What if?'" drawled a voice. "Our job is to have an answer."

This admirably down-to-earth sentiment was cooked up by the US Space Force, the newest arm of the US military, officially brought into being by president Donald Trump on 21 December 2019.

It has been the butt of jokes ever since. On 18 January, the Space Force showed off its uniforms to Twitter. Apparently there is a use for camouflage in space. Six days later, it revealed its logo, a sort of straightened-out, think-inside-the-box version of the Federation symbol from *Star Trek*.

Then, the coup de grace: Netflix announced it would be streaming a sitcom about the enterprise, created by producer Greg Daniels and actor Steve Carell.

A lot of expectation has been gathering around this fictional Space Force. Daniels's writing and production credits include the US version of *The Office*, *Parks and Recreation* and *King of the Hill*. Everyone is expecting a savage parody. So viewing is tempered with the realisation that the real Space Force will outcompete any television satire.

On the same day that the US Space Force's recruitment video was released, General Jay Raymond, its Chief of Space Operations, had a suggestion for Carell, who plays the Space Force chief in the series, General Mark Naird. "The one piece of advice I'd give to Steve Carell is to get a haircut," he grinned, during a webinar. "He's looking a little too shaggy if he wants to play [me]."

I'm glad he can see the funny side. While the fictional Naird and his head of science Adrian Mallory (John Malkovich) spar spiritedly over the launch procedures of one giant-looking rocket after another, in the real world the redoubtable Raymond is tasked with defending US satellites from laser and projectile attack from potentially hostile forces, on a start-up budget of $40 million. There are streets in London where that wouldn't buy you a house. Meanwhile, the total annual budget for the US military stands at $738 billion.

Space Force the sitcom is, likewise, a labour of love, produced on an obviously low budget. Its small satisfactions take a while to build. Naird's elevation means the family must relocate from Washington to an old military facility in Colorado (an "up and coming" state, according to Naird. His wife, played by Lisa Kudrow, sobs softly into her pillow).

At work, Mallory insists on taking two steps at a time when he climbs a staircase, even though his fitness isn't quite up to it: trust Malkovich to make comedy gold out of nothing.

> **"Space Force the sitcom, like the real-life Space Force, is a labour of love, produced on an obviously low budget"**

Other cast members underplay themselves. Improv comedian Tawny Newsome, as helicopter pilot Angela Ali, has too straight a role. *Silicon Valley*'s Jimmy O. Yang gets decent lines, but in demeanour he remains the soberest of Mallory's team of interchangeable scientists.

Trump wants boots on the moon. American boots. What does that mean? Naird, in a speech, tries to clarify: "Boots with US feet in them, I mean. Can't be certain where the boots will be made. Maybe Mexico, maybe Portugal."

This is the main point: what does it mean to make nationalistic noises about space when doing anything worthwhile up there requires massive international cooperation? In one episode, Naird demands to know what the foremost aeronautical engineering theorist in Belgium is doing on his oh-so-secret base. Gently, Mallory explains: The European Space Agency is in on the mission. Belgium is part of the European Space Agency. Belgium is part of Europe.

The show may not quite be the satire we expected, but there is real charm in watching gruff Naird slowly learn to express his feelings. ▮

AARON EPSTEIN/NETFLIX

Steve Carell plays General Naird, chief of the fictional Space Force

Watching your every move

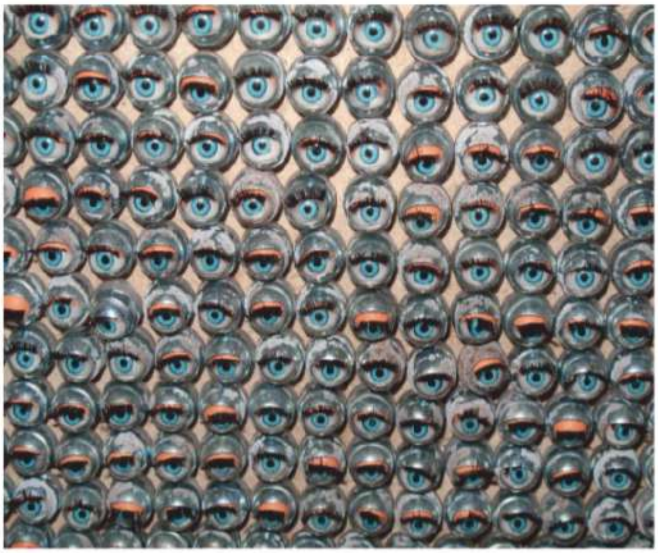
When everything is recorded, people become paragons of moderation. What could go wrong, asks **Sally Adee**

Book

No Signal

Jem Tugwell

Serpentine Books



In *No Signal*, everyone has a brain implant that keeps an eye on them at all times

PLAINPICTURE/NEVILLE MOUNTFORD-HOARE

A BUREAUCRAT navigating the pandemic would chew their right arm off for an iMe. No one leaves home without one in the world Jem Tugwell has built in *No Signal*, because each citizen has the device implanted in their brain.

Think of it like a smartwatch, tracking your location, exercise and calorie count while keeping you connected to social media. But thanks to a mix of nagging and coercion, this souped-up version actually stops you eating more than your recommended allowance or falling behind on your step count. Oh, and anything you do consume is filed automatically with the tax office.

***No Signal* is the second in a series, but works as a stand-alone tale. It is set in a post-Brexit Britain in which a high-profile event has driven the public into the arms of technological surveillance. Pretty soon, the implant is integrated into every fibre of governance and commerce, and having an iMe becomes the law.**

It has its upsides: no one can get lost, gain too much weight or develop an addiction. Yet breaking the rules gets you sent to a re-education camp. You emerge as a creature of moderation.

The book is set just as the first generation of iMe implantees have come of age: lithe, unburdened by bad choices, the picture of health. Not our protagonist, though – Clive Lussac is older and still remembers life before bad habits were cancelled. He is a detective, but what is left to detect? If, say, a woman is abused by her husband, their iMes' tracking information paints the only picture the police need. No one eats an extra bar of chocolate and no one gets away with murder.

It is a perfect Eden – except that the new generation's ability to evaluate risk has been blunted to nothing by a world without it.

If this sounds a bit like a social media rant by someone who is angry that society's needs are infringing on their individual freedoms, that is because the book is fairly explicit about hammering home these themes. Though the message rings true at first – yes, of course we shouldn't outsource our decisions to machines, even if that makes our lives more convenient – as the book grinds on, you find yourself with questions.

Lussac's suspicion of those without cravings for excess is as sculpted by culture as the iMe generation he holds in such contempt, shaped by a machismo that crams steak and beer down its throat to prove its commitment to individual liberty. Is that a choice? Or were those ideas formed by a system just as overbearing as the iMe nanny state he rebels against?

The book may not go down well with those who don't share Lussac's (and, one suspects, Tugwell's) sympathies. Yet the questions are worth examining from all sides as we decide how to respond to the coronavirus. How do you live inside a system's rules and still be happy?

Even now, tech is being made that seems like a precursor to the iMe: track-and-trace apps collecting data that may linger on government servers, for instance, and an experimental sensor that flashes when you get closer than 2 metres to another person.

Yet for all the concern about overreach – the sensor is being developed by a company perhaps appropriately called StrongArm – few agree with the protesters who insist that getting or passing on the virus is a matter of individual choice. When it comes to evaluating risk, the more people invited to weigh in, the better. Otherwise we might be sleepwalking towards an iMe. ■

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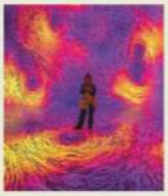

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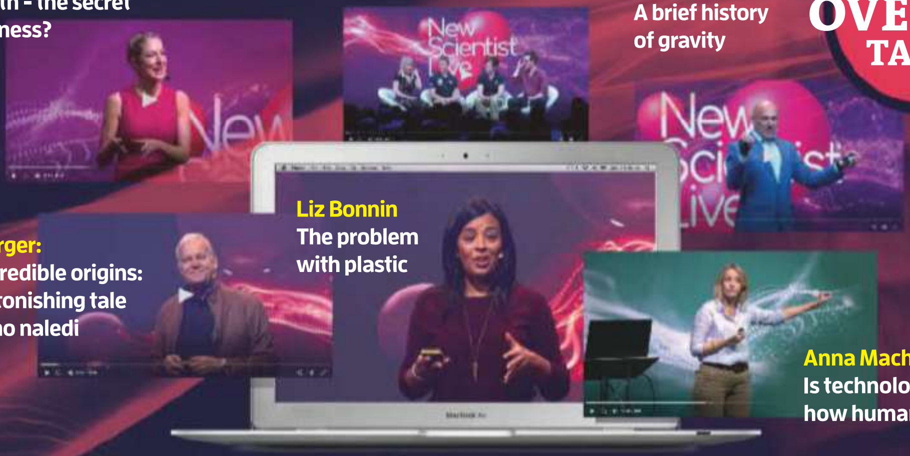

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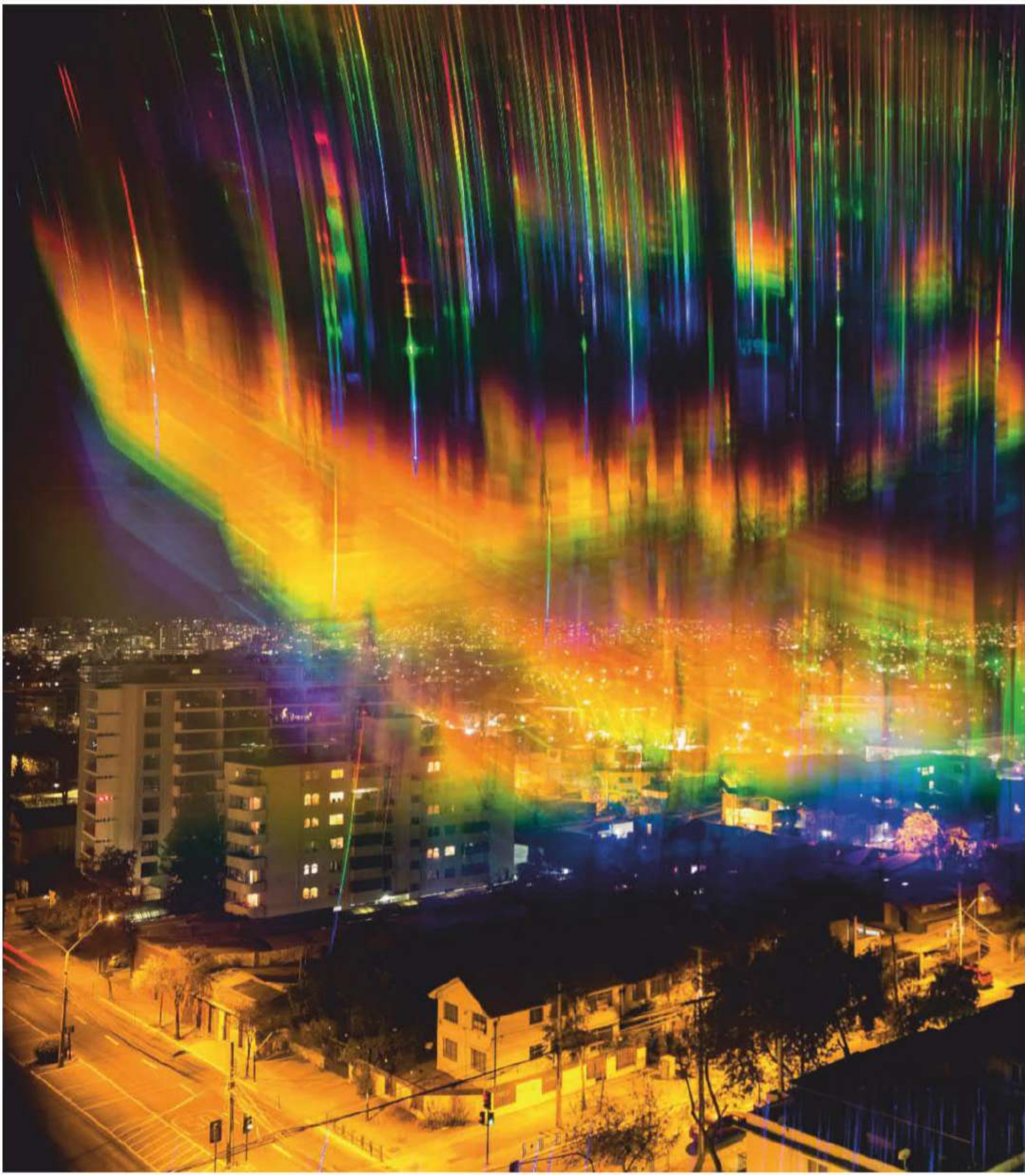
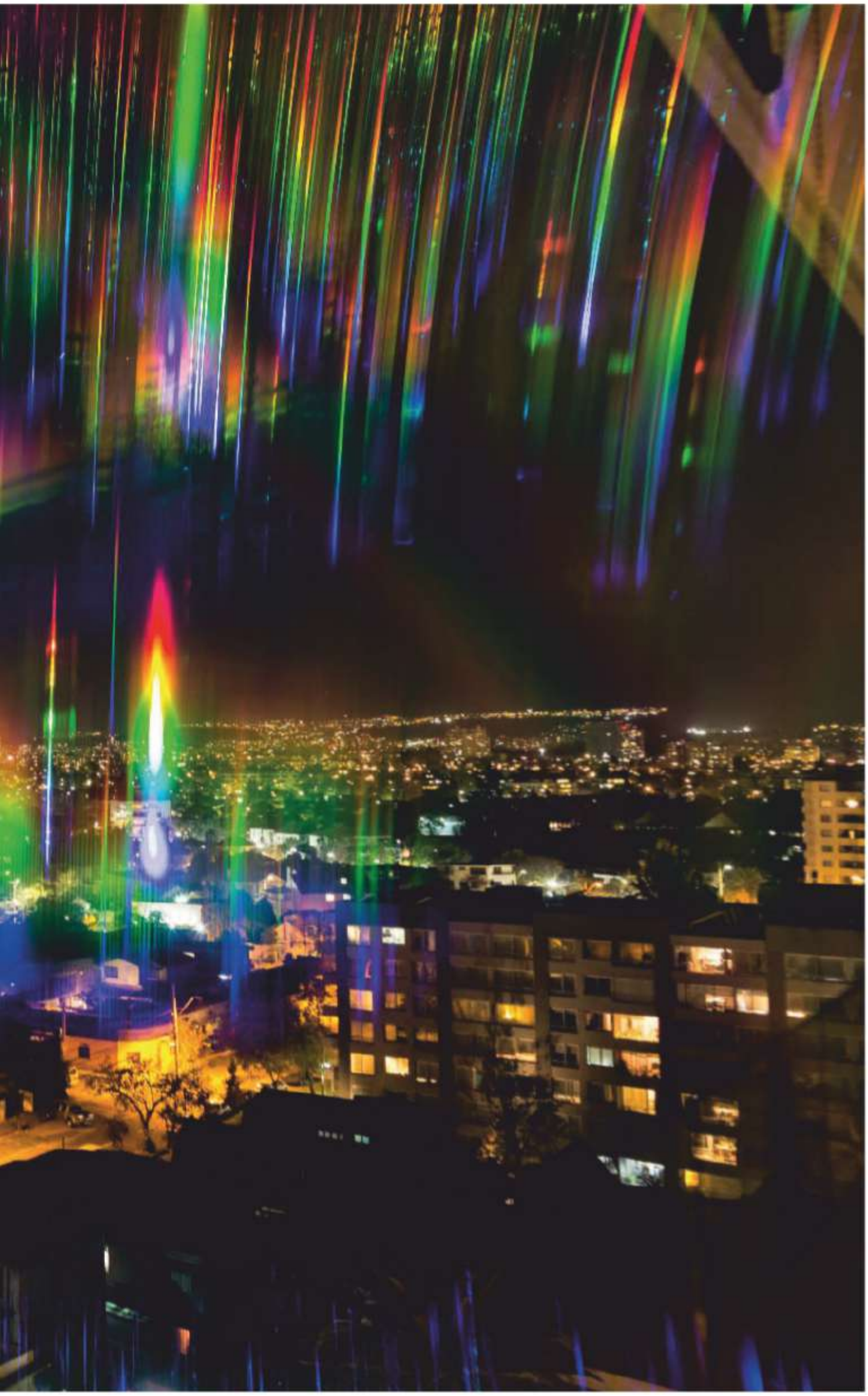




Undark skies

Photographer **Juan Carlos Munoz**

THIS kaleidoscopic shot of the night sky above Santiago, Chile, was taken during the city's lockdown and shows the extent of the capital's light pollution.

Astronomer Juan Carlos Munoz captured the view from his balcony. He tries to infuse every urban night photo he takes with a "gritty and other-worldly" feel, he says.

For this picture, he covered a lens with a diffraction grating, an optical element that is engraved with grooves that split the light spilling from the buildings and streets into different wavelengths in vertical streaks.

The result reveals the make-up of the city's various sources of illumination as a pattern soaring into the night sky. Sodium lamps have an orange spectra, metal halide lamps predominantly emit green, blue and violet light, while white LEDs are the brightest and emit across the visible spectrum (a good example is clearly visible just right of the centre of the photo).

Munoz says he takes such pictures to raise awareness of light pollution and hopes people can work together to illuminate cities in a more efficient way. "The night sky is a natural heritage that all citizens deserve to enjoy regardless of where they live, and therefore it must be protected from pollution, just like oceans or the atmosphere," he says. ■

Gege Li

"This is our chance to start bending the climate curve"

Could covid-19 be a turning point for global climate action? World weather chief **Petteri Taalas** is a man in the know – and he's optimistic, he tells Graham Lawton

TOMASZ MAJEWSKI

YOU might say the body Petteri Taalas heads determines the weather on world climate action. At the very least, it takes its temperature. The World Meteorological Organization (WMO), based in Geneva, Switzerland, is the United Nations specialised agency on weather, climate and water resources. It co-founded the Intergovernmental Panel on Climate Change, the clearing house for scientific research on global warming, and runs observing systems that follow what is happening to temperature, precipitation, storms, sea level rise, glaciers, snow and ice cover and greenhouse gas emissions across the planet.

The WMO has just produced its latest report, *The Global Climate in 2015-2019*. It comes a few short months after Taalas, the group's secretary general, found himself in the news for purportedly questioning the focus on the need for robust international action on climate change.

Graham Lawton: What did your report find about the state of the world's climate?

Petteri Taalas: So far, we have seen 1 degree [Celsius] of warming. During the past 20 years, we have seen the 19 warmest years on record. Last year was the second-warmest year since 1850 [when consistent records begin].

We have, again, been breaking records in greenhouse gases: carbon dioxide, methane and nitrous oxide. Of those, carbon dioxide is the most important. It has contributed two-thirds of the warming so far and its life in the atmosphere is several hundred years. Recently, we have been observing concentrations of the order of 415 parts per million; 400 ppm was once regarded as a critical level.

We have areas of the world where drought has become more frequent, including the Amazonia region, which may be bad news for the rainforest, and some areas with increased amounts of rainfall and snowfall.

We have also been monitoring what has happened to sea level. During the past century, sea level rise was typically 1 to 2 millimetres per year. During recent years, we have seen a rise of between 4 and 5 millimetres per year.

We have also seen glacier melting continue. Melting of the Greenland glacier increased threefold during the past 20 years, and the Antarctic ice cap has also started melting, which wasn't the case 20 years ago.

Many of the impacts of climate change and disasters are through water: groundwater problems, flooding, sea level rise and so forth. Those are having impacts on global food production capacity and human well-being, especially in less developed countries.

You also found that climate change is affecting human health.

During the past 20 years, we had seen positive development when it came to hunger, but during the past five years, there has been an increase again. Compared to 2015, we have 36 million more people who are suffering from hunger, more than 800 million people altogether. And there are something like 30,000 casualties on a daily basis.

Another result is that we have a growing amount of people who are exposed to heatwaves. Twenty years ago, we had about 20 million people exposed to

›

heatwaves on an annual basis. During the past three years, we have exceeded 200 million people per year. We have seen health impacts because of this. In the 2010 European heatwave, we got 50,000 casualties, mainly in Russia. In 2003, we had 75,000 casualties in central Europe.

What did your report, which predates the coronavirus pandemic, predict for the future?
We expect the trends we are already seeing to continue. Some estimates give a 10 per cent probability that we will reach the lower limit of the Paris Agreement [the international accord on limiting climate change, signed in 2016], a 1.5 degree increase, during the coming five years, at least temporarily. And since we have recently seen warming of the order of 0.4 degrees per decade, if that continues for the coming 10 years, it's very likely that we would exceed 1.5 degrees. That's somewhat striking.

You are known to be a climate optimist. Are you still one after this new report?
Yes, because the covid-19 crisis will change the world. It's going to have impacts on the mentality of people and governments. One could say that this is the mentality that would be needed in solving the climate problem.

You're saying that the pandemic proved that it is possible for the world to take the drastic action needed to stave off a climate crisis?
Yes, that's what I think. And actually, the good news is that you don't need such drastic action. The conversion of energy systems, transport systems and industry should happen gradually, not as dramatically as we have seen in tackling this crisis. We have much more time than with covid-19.

Governments are going to invest in recovery, and there's an opportunity to tackle the climate as part of the recovery programme. In the best case, we would invest in new types of climate technologies.

A pessimist would say that we will forget this problem and target our resources to economic recovery only. But there is an opportunity to start bending the curve in the coming five years.

We have heard much about positive environmental side effects of the pandemic. Can you put them into perspective?
We expect that there will be a drop in carbon emissions because of this pandemic crisis and its impact on industry and traffic, and so forth. But this is not going to have a major impact on climate because of the very long lifetime of carbon dioxide in the atmosphere.

There are many people who don't understand that the lifetime of these gases is very long, especially carbon dioxide.

But once we have been able to drop emissions, it's a question of whether we could continue along the same line in the future.

We have learned to telework, and that will reduce traffic emissions once you are not forced to commute every day to your office. We have had big international meetings by videoconference. The need to travel so much may be smaller after this experience.

There are also people who may have learned to be more modest in their consumption. If that is carried over, it would help us in tackling the climate problems. Personally, I'm optimistic. But let's see what happens in practice.

Shouldn't we focus on covid-19 for now and leave the climate crisis for later?
Covid-19 is causing casualties in the short-term, and there will be economic impacts of the order of a few years. But if we are not able to mitigate climate change, then we will see persistent health impacts and economic impacts, and the magnitude will be much higher than the ones that we are facing with this short-term crisis. If you compare casualties from hunger, the numbers are already much higher than the covid-19 casualties.

What is going on with the UN climate negotiations planned for later in 2020?
COP26 was supposed to take place in Glasgow this November. It's going to be delayed to next year. But what I have heard from the

DAVID BAGNALL/ALAMY

> "The good news is we don't need such drastic action on climate change as we did on covid-19"

Extreme floods, as in Ironbridge, UK, this year, is a cost of not tackling climate change

UK government is that its ambition still remains, and this meeting will be organised in the spring or fall of 2021. There's no intention to give up this climate mitigation mood that we have.

I imagine you hope the climate negotiations will resume as soon as possible so the present crisis is still fresh in people's minds.
I think that would be good, because now we have been facing this smaller-scale crisis, people may use the same sentiment in tackling this major, looming crisis.

You have previously said that you had detected a shift in sentiment on climate. Do you think that the current crisis has enhanced that?
Yes, that's what I think. The tone that I have heard so far, including from [UN secretary general] António Guterres and my colleagues in the UN, is that this sentiment that we're having globally at the moment would help us in mitigation for climate change.

We are also discussing with private sector players, who are critical. There was already a desire to be more active in mitigation efforts. I expect that will continue. In the US, we have a growing amount of private sector players who are interested in being part of the solution. We have also heard from major fossil fuel companies like BP and Shell that they have a target to become carbon neutral by 2050. So, good news.

Of course, the official US government position is quite passive, but many individual states have fairly ambitious climate mitigation programmes. And actually, the US has already fulfilled half of its Paris pledges.

It seems clear that deforestation and the wildlife trade let the virus jump into humans, and that there are more where it came from. Does climate change also make the risk of such zoonotic diseases worse?
So far, there's no evidence that links the covid-19 disease to climate matters. But some diseases are very sensitive to climate.

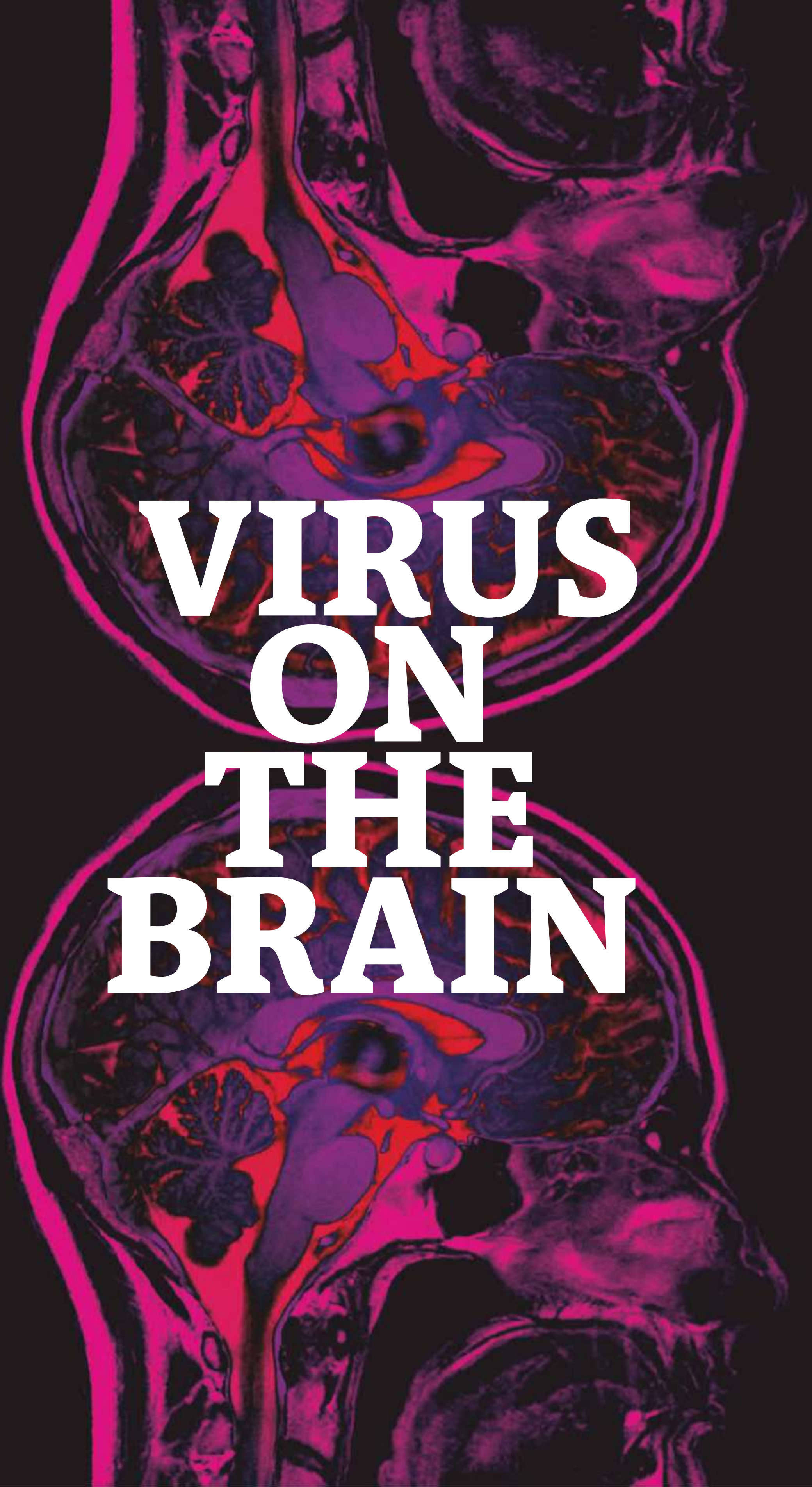
Dozens of diseases are somehow dependent on weather. And once we change the climate zones and patterns, we also change the regions where we can see outbreaks of some of these diseases. We used to have malaria in southern Europe in the past, and the return of malaria to Europe is one of the potential consequences. Cholera outbreaks are also related to weather.

You made headlines last year when it was reported that you had questioned the global focus on climate change in a newspaper interview in your native Finland.
I stated that some of the horror stories around climate science don't have a very solid basis, and some tipping points that some scientists have been promoting aren't the result of climate modelling. Personally, I believe in measurements or calculations. If certain risks are shown by the climate models, then they are, to me, real. Climate sceptics would be happy to see somebody who would question the climate science. That was one of the issues. There were some sceptics who were thinking that I'm not behind the UN climate reports, which is not the case. I was only questioning alarmist stories.

Finland seems to have been very successful in dealing with both the pandemic and the wider climate crisis. Do you think that holds any lessons for the rest of the world?
I think sometimes things are easier in a small country than a big country. And Finland is a country where it's often easy to find some sort of consensus. There are three or four bigger parties who form coalition governments, and the nature of the government work has always been that you are forced to find some compromises. That's not always the case in the USA or the UK, for example, where there are two parties that are sometimes in power and things are fairly black and white. In Finland, this kind of consensus approach may have been one of the positive things. ▮

Graham Lawton is a feature writer and columnist for *New Scientist*, and author of *This Book Could Save Your Life*

VIRUS ON THE BRAIN



Far from just affecting the lungs, covid-19 seems to cause a host of neurological problems. **Jessica Hamzelou** investigates

JENNIFER FRONTERA has been treating people in intensive care for years. But she has never experienced anything like covid-19 before. "These patients are absolutely among the sickest any of us have ever encountered," says the New York-based doctor. But the strange thing is, Frontera isn't a lung disease specialist or a virologist, she is a neurologist. And it is the possible impact of the coronavirus on our brains that is worrying her.

It was early in the outbreak in New York that Frontera and her colleagues began to notice neurological symptoms in those with covid-19. People were passing out before they were hospitalised. Once in hospital, some of them started having unusual movements. Some had seizures and others had strokes.

Similar reports are coming in from hospitals around the world. Some neurological symptoms appear to be mild, such as the loss of smell and taste. At the other end of the spectrum, a few people have developed encephalitis – a potentially fatal inflammation of the brain.

It is a surprising discovery in a disease that was generally considered to attack the airways, and one of pressing concern. One big question is how the new coronavirus is causing these kinds of symptoms. Growing evidence suggests that the virus may work its way into the brain, directly attacking neurons. If that is the case, we may need to reconsider some of the treatments being developed for covid-19. And we must also prepare for potential long-term and chronic neurological conditions in some survivors.

Millions of people globally have now been infected with the new coronavirus, SARS-CoV-2, but we are still learning how it works. What we do know is that it can be spread by droplets from an infected person and seems to latch on to receptors on cells in people's airways.

That might be the end of the story for the many infected people who experience either mild symptoms or none at all. But some will get very sick, showing flu-like symptoms that can progress to a severe pneumonia that leaves them struggling to breathe.

The official symptoms listed by the World Health Organization (WHO) initially included fever, tiredness, dry cough, sore throat, shortness of breath, aches and pains and, sometimes, a runny nose or nausea or diarrhoea. But in response to growing reports of people losing their sense of taste and smell, the WHO and US Centers for Disease Control and Prevention have expanded their lists of symptoms to include the loss of these senses. A study of 214 people hospitalised with the virus in China has found that 5.6 per cent had a temporary loss of taste, while 5.1 per cent had a temporary loss of smell.

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ZEPHYR/SCIENCE PHOTO LIBRARY

Reports from Europe suggest that these symptoms may be more common. A survey of 417 people treated at 12 hospitals across Belgium, France, Spain and Italy found that around 86 per cent experienced some change in their ability to smell, and 89 per cent had a "reduced or distorted" ability to taste flavours.

Other neurological symptoms are also showing up. Some people with covid-19 experience headaches and dizziness. Those with more severe illness can suffer seizures and strokes – even young people with no underlying conditions. Such outcomes are thought to be rare, although we don't have exact numbers. An assessment of 214 people hospitalised with covid-19 in China found that around 6 per cent of those with severe disease developed a condition that affected blood supply to the brain. "We've seen strokes and bleeds in the brain," says Frontera, who is based at NYU Langone Hospital – Brooklyn. There have also been a handful of reports of

MICHAEL DANTAS/AFP VIA GETTY IMAGES

A covid-19 intensive care unit in Manaus, Brazil, on 20 May

Post-mortem problems

Autopsies on people who died after having covid-19 will help to clear up many of the questions about whether the coronavirus can enter the brain and what it does there (see main story). But so far, only a handful of these examinations have been performed. "A lot of autopsy suites are not equipped to handle this kind of infection," says Avindra Nath at the US National Institute of Neurological Disorders and Stroke. "A lot of institutions have refused to do autopsies on these patients."

And for those that are performing autopsies, getting hold of brain tissue can be particularly challenging, says Desiree Marshall at the University of Washington, Seattle. "Removing the skull requires the use of a bone saw that produces aerosols [that could contain the virus]," she says. Such procedures should be performed in autopsy suites with special extraction systems that prevent air from passing to other rooms, and pathologists need adequate protective gear.

Marshall's team has so far performed four brain exams of people who died with covid-19. Of those, one appears to show signs of damage, with very small bleeds on the surface of the brain and in the brainstem.

Direct effects?

Michael Osborn, who oversaw the development of mortuary services at the newly created Nightingale Hospital at London's Excel Centre, has also been looking for post-mortem signs of damage inflicted by covid-19. So far, he and his team have performed full autopsies on six bodies. From these, they have discovered changes to blood vessels in the brain, which affect the amount of oxygen-rich blood that can get in. In these cases, brain tissue appears to have died because it hasn't received enough oxygen. But it is difficult to know whether this is a direct effect of the virus reaching the brain or a consequence of breathing difficulties.

Both teams will be looking for the virus itself in brain tissue. But that won't be easy, either. "Brain tissue takes a long time to process," says Osborn. Together, these challenges mean that we still don't know if the coronavirus is directly attacking brain cells. "We haven't found virus in the brain yet, but I wouldn't be surprised if other groups do," says Marshall.

brain inflammation and brain damage in people with severe cases of covid-19.

In some diseases, neurological damage is a knock-on effect of other problems within the body, not caused by the pathogen attacking the nervous system directly. But in this case, it is also possible that the virus could be working its way into the brain and nervous system. Plenty of other viruses that infect humans do this, including coronaviruses.

Pierre Talbot at the National Institute of Scientific Research in Quebec, Canada, has been studying coronaviruses since the 1980s. Much of his work has focused on two coronaviruses that are known to infect humans: HCoV-OC43 and HCoV-229E. Both often cause the common cold.

Finding a way in

We know that both can enter the nervous system and brain. "When I put [OC43] in the nose of mice, the virus goes straight to the brain through the olfactory nerve," says Talbot. "And when it gets to the brain, it spreads to all areas of the brain." Here, the virus can kill neurons and cause encephalitis.

Similar effects have been observed, but very rarely, in people infected with OC43. Talbot points to the case of an 11-month-old boy with a weak immune system who died with encephalitis. A biopsy revealed OC43 in his brain, implicating the virus.

When Talbot and his colleagues looked for 229E and OC43 in brain tissue from 90 people who donated their bodies to science, they found at least one of the two coronaviruses, and sometimes both, in almost half of the samples. Forty-four per cent of them had 229E in their brains and 23 per cent had OC43.

The SARS virus, another coronavirus similar to SARS-CoV-2, seems to act in similar ways. The first SARS outbreak took place between 2002 and 2003, claiming about 8000 lives. Like the coronavirus that causes covid-19, the SARS virus also causes lung disease and can lead to fatal pneumonia in about 10 per cent of those infected. But autopsies performed after the outbreak ended revealed that the virus could get into the brain. In 2005, a team looked at eight people who died with SARS and found the virus in all their brains.

And when researchers infected mice with SARS via their noses, they later found the virus in the animals' brainstems. The brainstem sits between the brain and spinal cord and regulates our breathing. "You can imagine that could further worsen the respiratory failure of these patients," says Igor Koralnik at Northwestern University Feinberg School of Medicine in Chicago, who studies diseases that infect the central nervous system.

What about the new coronavirus? A few reports claim to have found the virus in the cerebrospinal fluid of people with covid-19, which suggests it is getting into the brain and nervous system, says Avindra Nath at the US National Institute of Neurological Disorders and Stroke.

But there is a chance that the virus could get into a sample of this fluid without affecting the brain. If the virus is in a person's blood, this might contaminate the sample taken during a spinal tap, for example.

> **"Based on the evidence we have, it looks as if the virus is entering the brain"**

It is also possible that neurological symptoms may be caused by a lack of oxygen. People who die with covid-19 have a lot of damage to their lungs. The surfaces of small air sacs become thickened, making it harder for oxygen to get into the blood, says Sanjay Mukhopadhyay at Cleveland Clinic in Ohio.

This may also explain why those who survive covid-19 after being treated on a ventilator can show signs of brain damage in scans, says Frontera. This damage is probably a result of the brain being starved of oxygen.

The body's own immune response to an infection could also be to blame for damage to the brain. An overreaction of the immune system can lead to what is known as a cytokine storm – an extreme activation of immune cells that can lead to more inflammation, and damage organs.

But based on the evidence we have so far, it is reasonable to assume the virus is getting into the brain, says Nath. If that is true, it is vital we learn how the virus is attacking the brain. "It will make a huge difference [to how we treat patients]," he says.

At the moment, many antiviral treatments being developed for covid-19 will focus on getting the medication to the lungs. Getting drugs to the brain is an entirely different challenge. For a start, any treatments will have to cross the blood-brain barrier – a protective layer in the brain that controls what can get in. Most drugs can't do this. "It would be a totally different treatment approach," says Nath.

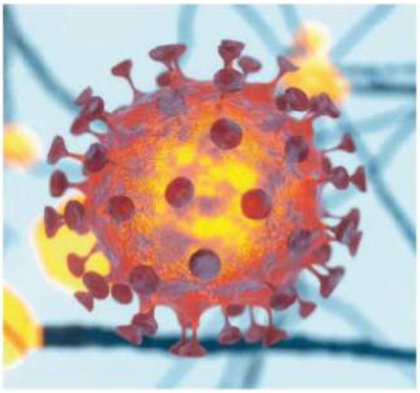
If the virus is accessing the brain, it could have long-term neurological consequences. We know that some viruses can hide in neurons, reactivating to cause disease later in life. Herpes simplex viruses, for example, typically cause cold sores or genital blisters. But in some people, they can trigger inflammation of the brain. Once a person has been infected, the virus lays low in their neurons and can reactivate throughout life.

"It's not impossible that [the coronavirus] could have the same kind of persistence in › the brain," says Talbot. "We have seen OC43 and 229E in the brains of humans, and the virus seems to be hiding there – it's possible that upon reactivation they could cause neurological disease."

Some neurological effects are likely to have a lasting impact on people who recover from covid-19. Strokes and seizures can cause brain damage with long-term consequences, for example, and many of those who experience such outcomes will need follow-up care and rehabilitation.

The virus could also cause longer lasting secondary problems. Some might be in the form of post-viral fatigue syndromes.

There is also concern about Guillain-Barré syndrome, which is characterised by poorly functioning peripheral nerves. "It's like an ascending paralysis," says Nath. "It starts with the feet and goes up." Some cases are temporary, but other people experience lasting disability and it can even be fatal.


JIAN FAN/GETTY IMAGES

Coronavirus in the central nervous system could cause lasting effects

There is growing evidence that Guillain-Barré can develop in some people who recover from covid-19. So far, there have been reports of this in several countries. For example, across three hospitals in northern Italy, over a three-week period in March, doctors noted five cases of Guillain-Barré out of between 1000 and 1200 people treated for covid-19. "That's very significant. About a thousand times more than what you'd expect in the population [in the absence of covid-19]," says Koralnik. "We're probably going to see many more such cases."

It isn't clear who is at risk of developing neurological symptoms or secondary disorders. But what is clear is that many people who are hospitalised with covid-19 and then recover will need to be followed up by healthcare providers, possibly for years.

Some of Frontera's ventilated patients are already showing signs of severe brain damage. "The possibility of them waking up seems extremely low," she says. The prospects for less severely affected people are still unclear. "We're still learning about covid," she says. "It will take a few months before we have a good idea of the prognosis."

Apart from a temporary loss of smell and taste, most of the neurological effects seem to only occur in very severe cases of covid-19. Although we don't yet have exact figures, it seems that only a very small fraction of people experience damage to their brain and nervous system. But it is possible that, for some people, brain effects will be lasting, says Nath. "Brain diseases can really affect who we are – they can change our personality, can affect the way we walk and move and cause all kinds of long-term consequences," he says. "Even if it's only in a small percentage of individuals, the devastation can be quite phenomenal. We should not take it lightly." ▮

Organ impacts

Covid-19 is first and foremost a disease of the airways, causing severe harm in the lungs.

But doctors have been seeing signs of damage right across the body. While hospitals were attempting to increase the number of ventilators they had, they were running out of dialysis equipment for covid-19 patients experiencing kidney failure.

Gastrointestinal problems have been seen too. And while many people are thought to die from a lack of oxygenated blood as a result of their breathing difficulties, some of these people are in fact dying with multi-organ failure, such as damage to the heart and liver.

What is going on? It is possible that the virus behind covid-19 is reaching multiple organs by travelling through the bloodstream, says Sanjay Mukhopadhyay, at the Cleveland Clinic in Ohio. The virus is known to get into the lungs, which have a rich blood supply. "It's very easy for these infections to get into the bloodstream," he says. "Once the virus is in the blood, it can get to any organ."

Whether the virus is directly damaging those organs is another question. Organ failure frequently results from serious illness, often as a result of the actions of the body's own immune system. Ventilated people, struggling to get enough oxygen into their blood, are particularly at risk, says Mukhopadhyay. "When people develop that degree of severe lung injury, many other organs fail," he says. "This is not unique to covid." Pathologists including Mukhopadhyay, are now beginning to look for the presence of the virus in organs donated by people who died with the disease.

Jessica Hamzelou is a *New Scientist* reporter. Follow her @jesshamzelou

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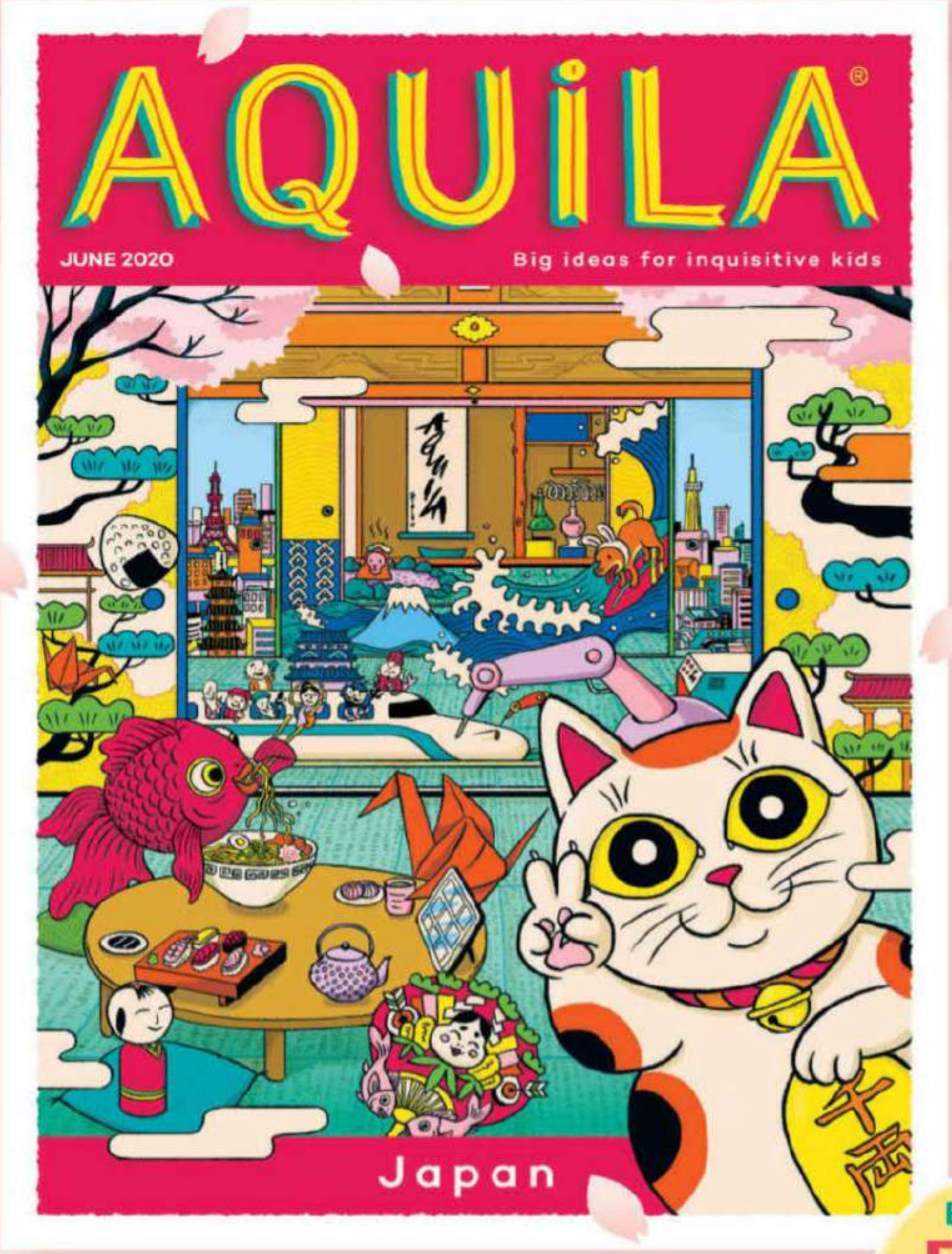

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Lost meteorites of the Antarctic

Space rocks carrying crucial clues to how our world began could be hiding in Earth's most extreme wilderness, says **Joshua Howgego**

ROMAIN TARTÈSE/THE UNIVERSITY OF MANCHESTER

Another meteorite is plucked from the Antarctic ice

A BEEP sounded in Katherine Joy's earpiece and a light flashed on her handlebar display. The metal detector dragging behind her snowmobile had found something buried in the thick Antarctic ice. She dismounted. Could this finally be it?

A convoluted story had brought Joy and her fellow treasure hunters here, 700 kilometres south of the British Antarctic Survey's Halley VI research station. You might say the story started 4.5 billion years before, as a result, probably, of a massive star going supernova. Its rumbling shock wave caused a cloud of dust and gas laced with heavier elements to begin to collapse in on itself, eventually forming the sun and the planets, moons, asteroids and, eventually, other components of our solar system, like us.

For decades, researchers have been hunting for pristine material from these turbulent times to better understand exactly how these processes occurred. Joy and her colleagues had ventured out into the Antarctic wilderness following a hot lead to fill a crucial gap in the tale: the mystery of the missing meteorites. What they found, however, wasn't one mystery, but two.

Meteorites are time capsules from the solar system's birth. They are mostly fragments of asteroids that orbit between Mars and Jupiter, plus the occasional unsullied piece of the moon or Mars that has come unstuck and crossed Earth's orbital path. These

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DUSTING THE ROOFTOPS

Iron meteorites aren't the only bits of space rock we have difficulty locating (see main story). Every day, Earth is bombarded by countless micrometeorites. Each is roughly the size of a full stop, but a day's worth weighs in at an estimated 100 tonnes.

A phenomenon known as the Poynting-Robertson effect means these small particles get sucked in towards the sun, potentially crossing Earth's orbit. Because of this, they come from a wider spread of space. They thus give a much broader feel for the chemistry of the early solar system than standard meteorites, which largely come from the asteroid belt between Mars and Jupiter. "The difference between looking at meteorites and micrometeorites is like looking at a piece of the jigsaw or looking at the whole puzzle," says Matthew Genge at Imperial College London. But their size makes them hard to find.

Enter one of Norway's most famous jazz guitarists, Jon Larsen. Whereas researchers typically go to pristine areas such as the bottom of the sea or Antarctica to collect micrometeorites, he was convinced he could gather them using a magnet wrapped in a plastic bag on the rooftops of Oslo, and contacted Genge for help.

Ideas similar to Larsen's are popular among some amateur astronomers, and aren't beyond the pale: micrometeorites do fall on urban rooftops. But then so does a lot of other dust in the form of pollution, making the search for them there seem like a fool's errand. "My intention at first was to convince him this was a bad idea and to basically make him go away," says Genge.

But Larsen persisted, scouring through three rubbish bins' worth of metallic dust he had collected and sending Genge pictures of tiny spheres that looked promising. Some of them began to catch Genge's eye. Eventually, the pair had amassed 500 of what they believed to be micrometeorites. Chemical analysis of a sample of 48 indicated that all 500 were probably the real deal.

These days, Larsen runs Project Stardust, a Facebook community of people who hunt for micrometeorites and share their finds. Every so often, a picture of a new type is posted. "It's a bit like birdwatching," says Genge. And the more we find, the more likely we are to find a truly exotic migratory specimen: by Genge's reckoning, about 1 in 5000 micrometeorites must originate outside our solar system in interstellar space.

fragments have existed more or less untouched since bits of rock first began to accrete from smaller dust particles as they whirled around the infant sun. With their chemistry unadulterated by the tectonics, volcanism and other violent processes of Earth, they preserve vital clues as to how the solid parts of the solar system formed.

We know lots of individual details about what must have happened as bits of rock crashed together and aggregated to form larger bodies, or sometimes split apart again in the maelstrom of the early solar system. But we lack a convincing, unifying picture. "We don't have an equivalent of, say, evolution by natural selection in planetary science right now," says Luke Daly at the University of Glasgow, UK. "We don't have a good theory that takes us all the way from gas and dust to planetary systems."

Iron pilings

Meteorites come in a wide variety of shapes and sizes, from the 60-tonne Hoba meteorite, discovered in Namibia in 1920, to the tiny specks of dust constantly raining down on our planet that present their own difficulties to researchers (see "Dusting the rooftops", left).

The vast majority of meteorites found worldwide are stony, made mainly of dull-looking silicate rock of the sort that makes up the bulk of a planet like Earth. Then there are the stony-iron meteorites, formed of a mixture of rock and metal. A striking example of these is the Imilac meteorite that was found in the Atacama desert in Chile hundreds of years ago. Remnants of it held in London's Natural History Museum look like dazzling slices of extraterrestrial stained glass.

The third category comprises the iron meteorites, made of a mix of iron and nickel. The Hoba meteorite is the largest known example of this type, which is particularly crucial to understanding the solar system's origins. For a lump of iron and nickel to have formed, it must at some point have been part of a space rock that grew so large that its innards melted, allowing heavy metals to sink to its core and less dense rock to rise.

A similar process of differentiation created Earth's dense, partially liquid iron-nickel core surrounded by a mantle and crust of silicate rock. The moving liquid metal in these early space rocks would have generated a magnetic field, just as Earth's churning core does today. Iron meteorites are fragments of these early cores. By looking at preserved traces of the magnetic fields now frozen in them, we can work out how large their parent rock must have been – and so how, and how quickly, the process of planet formation progressed.

"They're a really enigmatic and interesting group to study because they're the only way we can actually think about planetary interiors," says Claire Nichols at the Massachusetts Institute of Technology. "The more samples we can possibly get our hands on, the more we can learn about how planets work."

Whatever type of meteorite you are interested in, Antarctica is far and away the best place on Earth to look for them. Its frozen surface is largely pristine and untouched for millennia. Interior glaciers

NEIL LUCAS/NATURE PL

Antarctica's majestic expanses could hide clues to the solar system's beginnings

> **"Antarctica provides two-thirds of all meteorite finds on Earth"**

act like a conveyor belt, slowly carrying any rocks that fall on them down from the high points of the East and West Antarctic ice sheets towards the Transantarctic mountains, a range rearing out of the ice that divides the two regions as it slices across the continent. As the glaciers butt up against the mountain rock, they force ice and any space rocks trapped within it up to the surface. Each Antarctic summer, from October to February, teams from around the world head south to harvest them. The continent provides almost two-thirds of verified meteorite finds made on Earth.

But here's the thing: discoveries of iron and stony-iron meteorites, rare at the best of times, are almost non-existent in Antarctica. Why this should be is a mystery that has stumped many meteorite hunters, and one that hampers our attempts to construct a convincing story of the early solar system (see "Precious metal", page 44).

Geoffrey Evatt never intended to get mixed up in this problem. A mathematician at the University of Manchester, UK, he began his career developing models of the dynamics of glaciers mainly because he liked mountain climbing and the outdoors. He first heard about the missing meteorites by chance at a scientific meeting. "At that point, I wouldn't have known a meteorite if it had hit me on the head," he says.

Things really kicked off in 2012 when Joy, an old friend and climbing buddy of his, moved to the University of Manchester. She just happened to be a meteorite expert. Discussing the mystery, Evatt and Joy hit upon a possible solution to the problem.

It went like this. Metal meteorites are

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> **“The lost meteorites may have been right in front of our noses”**

much better at absorbing heat than stony ones. As the glaciers pushed them upwards at the base of the mountains, they would begin to absorb more sunlight, warm up, melt the ice around them and sink again. Unlike other types, metal-rich meteorites would remain perennially trapped a few centimetres beneath the surface. In other words, they aren’t missing at all – just hiding.

The pair tested the idea by shining sunlight-simulating lamps on a stony and an iron meteorite in ice. Sure enough, the iron meteorite sank. “We’d gone from a bonkers theory to a point where we actually had evidence to explain the absence of the iron meteorites,” says Evatt. It was enough for him and Joy to secure a grant to put together a larger team to build some kit – a metal-detecting array commonly used to clear landmines, adapted and towed by a snowmobile – and go meteorite hunting.

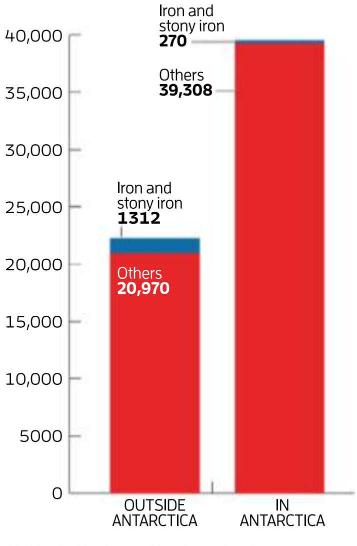
By 2019, after a test in the Arctic and a first reconnaissance trip to Antarctica, the search was on in earnest. “Meteorite hunting is the best thing in the world,” says Joy. “You’re rocketing up and down over this quite bumpy surface, avoiding ice patches and looking around. And when you spot a meteorite, you kind of jump, the heart lifts a little bit.”

Things didn’t pan out quite as expected, however. The metal-detecting rig got badly bashed up by the bumpy ice, requiring frequent repairs. And while the researchers found lots of meteorites on the surface, about 130 of them all told, they didn’t discover any in the ice. Even that promising moment when Joy’s earpiece beeped was just one of many false alarms, caused by a metal screw that had fallen off her rig.

KATHERINE JOY/THE UNIVERSITY OF MANCHESTER

Precious metal

Almost twice as many meteorites have been found in Antarctica as elsewhere in the world, but rare iron-bearing specimens are inexplicably hard to find there



SOURCE: LPI.USRA.EDU/METEOR/ AND KATHERINE JOY

But there was an odd twist in the tale. Many of the rocks are still on a ship heading back to the UK for full analysis, but based purely on appearance, there are far more iron-rich meteorites among the surface finds than anyone expected. “It seems, in a very preliminary way, like we may well have found the lost iron meteorites of Antarctica,” says Evatt. “But for this particular area, they were right in front of our noses.”

Which means there are now two mysteries. The first is why the researchers failed to find any meteorites beneath the ice. It could be that their hypothesis and successful lab tests led them down the wrong path, or perhaps their equipment troubles meant they just hadn’t searched a wide enough area. The second mystery is why, comparatively, they found so many iron-rich meteorites on the surface when so many others before hadn’t.

Fluke find?

The Outer Recovery Ice Fields, as Evatt and Joy named their stomping grounds, hadn’t been searched before, and the discoveries could be a statistical blip: the small area they searched may have just had a larger than average concentration of iron meteorites. It might not say anything about Antarctica more generally. Alternatively, it could indicate some subtle shift in the ice dynamics, perhaps as a result of climate change – though Joy, for one, thinks that is unlikely, as the effects of global warming are only just being felt in the Antarctic interior.

Beginning to find answers will require a more conclusive analysis of the researchers’ haul. “We haven’t begun to ask these

YVA MOMATIUK & JOHN EASTCOTT/MINDEN/NATURE PL

Ice movements churn meteorites towards the feet of the Transantarctic mountains

questions ourselves yet because we don't know what we've found," says Joy. Whatever the exact make-up of the meteorites turns out to be, however, planetary scientists are rubbing their hands. "Given that they've just been sitting on the ice, they're highly pristine, so I would argue these are more valuable, probably, than a lot of what we have available at the moment," says Nichols. James Bryson at the University of Oxford agrees. "I would totally be interested in getting hold of these meteorites once they have classified them," he says.

The question then becomes whether the trove is a fluke or if we can find more of this precious cargo. That will mean venturing back into the field armed with whatever new information the samples provide to inform the search. Joy says that she is currently exploring sources of funding for a longer-term programme, and that other teams are welcome to replicate their search equipment and go foraging on the ice themselves.

If that happens, it won't be for a few months yet. As Antarctica slips into the depths of its winter, no one is venturing out to the lonely interior glaciers for answers right now. But their slow movements will continue to churn more rocks from the dawn of our solar system down towards the mountains. When winter turns into summer once again, some more could be just waiting for someone to pick them up. ▮

Joshua Howgego is a features editor at *New Scientist*

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FINDING YOUR PHYSICAL INTELLIGENCE

Our brains' fluid interactions with the world around us are a understudied element of human success – one best appreciated in the wild, says neuroscientist **Scott Grafton**

How do you decide if you can drive through a snowstorm? How high are you willing to climb up a ladder to change a lightbulb? Can you prepare a dinner party for eight? When was the last time you discovered a shortcut through a forest?

For all these challenges, there is only one way to find out. A person needs to devote some time, energy, and physical engagement. Smart talk, texting, virtual goggles, reading, and rationalising won't get the job done. The hands have to be on the wheel of the car to learn the feel of slipping tyres. The feet need to be balanced on the ladder rungs to detect the tipsiness. The cook has to already know how to chop, fry, and combine four complicated recipes so they are all finished by a certain time. Finding a shortcut through the forest demands vigilance, courage, and the ability to keep one's wits, particularly at that moment of self-doubt when the journey seems more like a longcut than a shortcut.

Skills such as these are informed by "physical intelligence": the components of the mind that allow anyone to engage with and change the world. Inside the brain there is no single module or bit of tissue that makes this possible. Instead, the action-prone mind draws on a multiplicity of capabilities. Some are almost primordial in their simplicity. How come you don't walk into walls or off of cliff edges? Others are quite subtle. When you take on a new do-it-yourself project, how much of your problem-solving relies on old habits, winging it, or careful reasoning?

Our psychological intuition about how the brain works inevitably places verbal thought and all the stuff we can talk about, such as our emotions, at the top of the heap. Physical intelligence, which is largely inaccessible to conscious introspection, is treated as a lower form of intelligence, something to be tucked beneath the verbal and largely ignored. But physical intelligence is much more. It is foundational, a kind of knowing that frames much of what the mind spends its time engaged in. Indeed, the fact that so much of physical intelligence can be performed beyond consciousness is the very design feature that frees our thoughts so we can spend our day thinking about social affairs, work, and the world of ideas. Under all the verbal chatter of the mind, much if not most of what the brain is actually dealing with is the raw physicality of being alive.

For many of my colleagues who study the mind, the very notion that physical action also requires some intelligence draws a blank stare. They focus on thinking and perceiving. Other than ears and eyeballs, the body is largely irrelevant for their kind of science. However, to study a mind without a body ignores some of the greatest pleasures of being alive: experiencing the world directly, as we perform and create. My patients point this out to me time and again. As they lose various physical capacities they also lose bits of their deepest sense of self.

One of my patients was a farmer in south Georgia with advancing Parkinson's disease. There came a sad day when I had to take his driver's license away. Driving has a way of projecting a person into the physical world, providing a dizzying sense of freedom. For good reason, then, the farmer was severely depressed when he lost his privilege. However, he was not to be deterred. Denied one of his greatest joys, he found an intimidating but satisfactory substitute: he could still drive his oversized bulldozer around his farm. For him, thinking, philosophising, and reasoning would never offset the sheer joy of getting out and about in his vehicle. Even Stephen Hawking yearned for action. He once commented, "Obviously, because of my disability, I need assistance. But I have always tried to overcome the limitations of my condition and lead as full a life as possible. I have travelled the world, from the Antarctic to zero gravity."

The hidden nature of physical intelligence poses a problem for the scientist. How can these capacities be exposed for what they are? To a certain degree, all of us are constantly searching for them. We are drawn like moths

›

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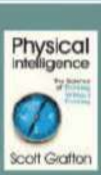

SCOTT GRAFTON is director of the Brain Imaging Center and co-director of the Institute for Collaborative Biotechnologies at the University of California, Santa Barbara. This extract is taken from the introduction of his new book *Physical Intelligence: The science of thinking without thinking*, and is reproduced by permission of John Murray & Sons

to a flame whenever we witness physical brilliance, when brain, mind, and body operate together with singular grace, as is sometimes evident in sports, dance, craft, or music. However, a scientist focusing only on superb physical talent can be led astray. It would be as if she were trying to understand language by only studying winners of spelling bees. All of our physical intelligence, not just that of outliers, needs to be explained. Look closely at the barista, the kid playing hopscotch, or the floor mopper and you will soon begin to notice physical brilliance everywhere.

Long ago I discovered that some of the most important components of physical intelligence, the ones that are generalisable and relevant for all of us, are laid bare when one is alone in the natural world, particularly in the wilderness. Venturing into wild places requires enormous ingenuity and resolve. It is the primordial world we originated from as a species, and thus it makes sense that the cognitive capacities that are of greatest value for goal-oriented behaviour should come to the forefront there.

I make a yearly trip into the wilderness alone, to the Sierra Nevada. A good wilderness trip needs three things for the properties of physical intelligence to be evident. The first is obscurity. Although I had left a map and a detailed itinerary with my wife, I changed my route on the second day of my trip. If anyone went looking for me using the map I had given her, she would probably scour an area that was more than twenty miles away, beyond two glacial divides. Mobile phones don't work in these parts. And the Park Service is so understaffed, the likelihood of being rescued in a crisis is abysmally low. Without any of these lifelines, a relatively simple hiking trip can suddenly become a profoundly intense and complex experience.

The second feature is solitude. On such a trip, there is none of the wonderful chatter and distraction that dominates the closeness and pleasure of an outing with family and friends. Without these entertaining social connections, a solo trip results in an utterly different kind of experience. It is not a lonely one. Rather, the solitude provides time for reflection and an opportunity to examine the kind of intelligence that informed human action as our species evolved. In addition, a trip alone completely changes the stakes and perceived risk. There is no confusion about responsibility. The traveller owns all his or her decisions.

Roughness is the third feature. The familiar world is stripped bare; the setting is primordial. The landscape is open and stretches forever, with barely a trace of human influence. For more than 1.3 million years of evolutionary history, this was the ordinary world. There were no level sidewalks, warm houses, or high-rise luxuries. Nothing mitigated risk, eliminated hazards, or minimised effort. Our ancestors evolved in a world that was nothing but wilderness. This landscape endowed our species with remarkable ways of seeing, interpreting, and acting in challenging environs. With that in mind, when I take what are relatively hazardous and unknown explorations into the mountains, I get to experience a very crude simulation of what being alive was like long ago. Survival is paramount and one is ever mindful of it.

We didn't emerge as a species sitting around. We wandered far and wide, into locales that are almost unimaginable. To really understand physical intelligence, you need to wander. On a previous trip, I climbed one of the southernmost fourteen-thousand-foot peaks of the range I have spent my life roaming in. It was a very long, steep, ten-mile ascent requiring a windswept traverse far above the shelter of trees and running water. Just before the summit, I was surprised to find an obsidian arrowhead.

The setting was desolate, remote, and cold. For many scientists, the arrowhead itself would have been critical. The object reveals something about the cultural intelligence of the hunter, his best technology, available resources, and trading network. The object could have been left there two hundred or nine thousand years ago. What interests me is not the specific manufacturing

“Physical intelligence requires constant learning processes”

advances revealed by the arrowhead or how big the trading network must have been for it to show up in the region.

For me, it’s rather the ridiculous location where I found it. The owner probably would have been a Paiute Indian who stalked a deer or mountain goat all the way to the summit, the far side of which ended in cliffs, effectively forming a trap. The hunter had readily climbed through this massive, unforgiving landscape at will, with stunning competence. To me he is amazing not for his technology but for his sustained confidence in stalking, tracking, and climbing over increasingly rough terrain while intensely exposed to sun, wind, or snow. All for dinner. When I roam through the middle of nowhere, the kind of intelligence he and countless generations of ancestors drew on becomes easier to appreciate. The point of my trips is to wander through an environment that makes the natural relationships between thinking and acting obvious.

To get a good glimpse of what people were like when physical intelligence was honed, one has only to look to the “Iceman,” Ötzi, a mummified hunter who died five thousand years ago just below a high mountain pass on the current Austrian-Italian border. Ötzi’s remains are on display at the Südtiroler Archäologiemuseum in Bolzano, Italy, along with his fur-covered bearskin hat, goatskin clothing, copper-tipped axe, backpack, food scraps, medicine, fire-starting tools, and longbow. Only five feet three inches tall and with an entirely ordinary albeit fit physique, he readily travelled alone and self-sufficiently through the middle of the Alps. He could smelt copper. Take down a large elk. Fabricate Neolithic blades. Travel over glaciers without getting frostbite. He yields a startling view of our past. What we consider to be extraordinary—living in an Alpine wilderness—was entirely ordinary at the time. Ötzi relied on a complex of mental capacities that allowed him to adapt his behaviour constantly to meet the demands of an extreme and highly varied environment. Ironically, what led to his demise was not the rigour of an extreme mountain environment; it was someone shooting an arrow into his shoulder.

The basic properties of the mind that kept ancestors like Ötzi alive continue to manifest themselves in all of us. A common thread is the special role that learning plays in forming this kind of intelligence. The mental capacities that are used for action are, more than anything, different kinds of learning machines that the brain has available for acquiring and maintaining physically derived knowledge. Physical intelligence is absolutely ruthless in requiring that knowledge be gained from direct physical experience. This is profoundly different from, say, the instantaneous remembrance of a face, name, or phone number. Rather, physical intelligence reflects learning processes that constantly tinker with a person’s performance. One never stops learning to cook, to drive, or even to walk, for that matter. It is also a knowledge that is lost from disuse: without practice you will fall on ice or off ladders.

The world Ötzi navigated was physically challenging and complex, characterised by palpable tension arising from an inability to predict what might happen and few means for main¬taining control. Here were perfect conditions for improvising, inventing, and enduring some of the most rigorous demands of the wilderness, which lay at the heart of what shaped physi¬cal intelligence for aeons. Although the wild is uncontrolled, physical intelligence provides the means to establish a sense of control. Humans acquire their skills and learn to solve problems through constant physical experimentation. That was as true for Ötzi as it is for us. There is no end to the sensing, adapting, anticipating, and accommodating that must take place for a person to act intelligently. It takes practice and know-how to do even the little things in life: to stay upright on a slippery sidewalk in front of your home or to know whether you can still climb a ladder without falling off. And most of all, physical intelligence provides the means for experiencing the pure joy of figuring out how to do something for the first time, whether it is building your first campfire or catching your first fish. ∎

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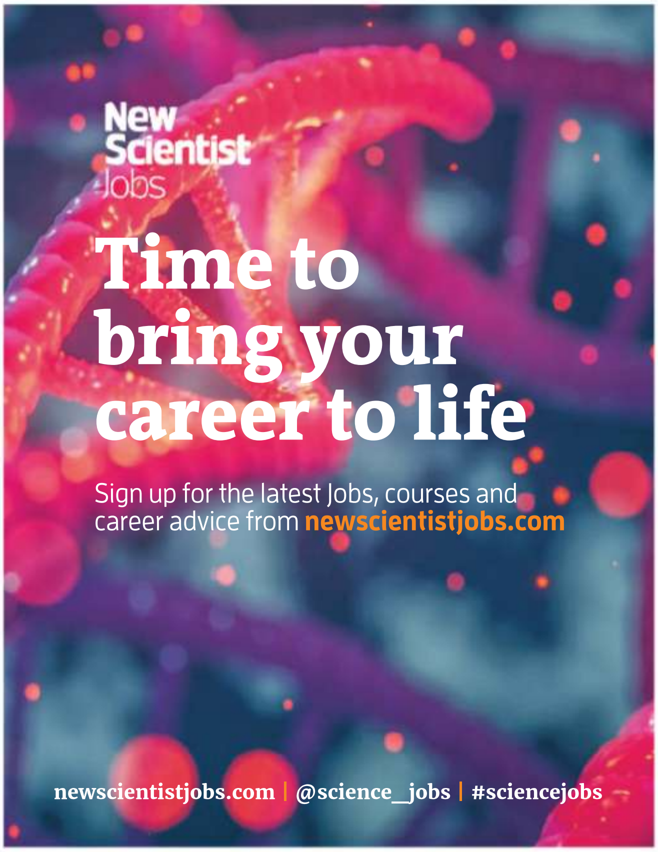

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The back pages Puzzles

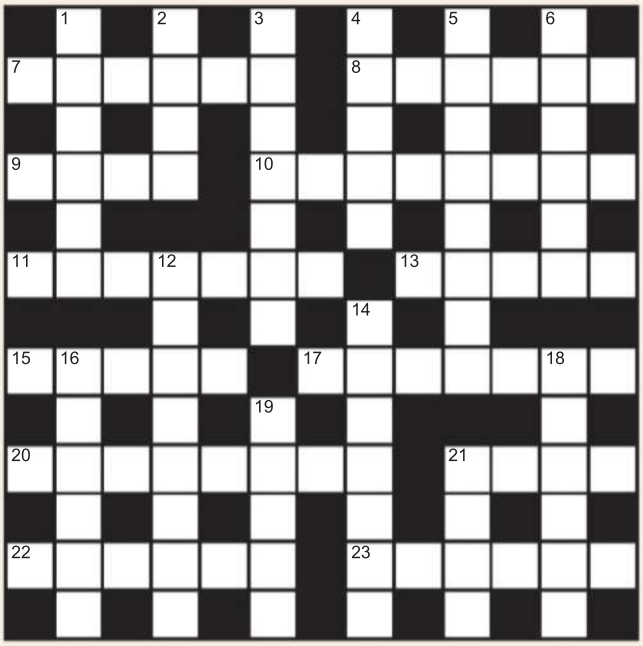
Puzzles
Can you solve the age-old challenge of the Triple jump? p54

Cartoons
Life through the lens of Tom Gauld and Twisteddoodles p54

Feedback
It's not rocket science, it's a euphemism, plus pi in the sky p55

The last word
Why do we often dream about falling? Readers respond p56

Cryptic crossword #32 *Set by Wingding*



Scribble zone

Answers and the next quick crossword next week

ACROSS

7 Involve part of placenta illustration (6)
8 A beast of burden Isaac analysed, initially finding a lack of oxygen (6)
9 Study concerning origins of astronomical data (4)
10 Family gets into Sinatra song where we play among the stars? (5,3)
11 Complex character once eviscerated by detective and tailless cat (7)
13 Second car for Bin Salman, maybe (5)
15 Group collect stockpile, we hear (5)
17 Report in poor taste about something going faster than light (7)
20 Baked crumpets, a phenomenon that fascinated Newton (8)
21 Have a drink when Newton is expelled by motion (4)
22 You and I leave European country with student of stars (6)
23 Heads of Tesla and Twitter tussle over offensive display (6)

DOWN

1 Addition of gas under queen (6)
2 Newton embraced by dismal musicians (4)
3 Lousy PM getting dizzy in high place (7)
4 Sailboats change direction: left, south (5)
5 Nothing interrupts work on arithmetic for Newton, perhaps (8)
6 Leucine, immunoglobulin and DNA unravelling a molecule that binds to a receptor (6)
12 Isaac Newton doesn't understand chemistry, early reviewers said at first, referring to activating molecules (8)
14 Mother insect, an enormous creature (7)
16 After surgery, sit and resist (6)
18 Prayer for son among the stars (6)
19 Working class person's job under pressure (5)
21 Hole in the ground accommodates most crossword compilers (4)

Reading around the perimeter from square 1 is a quote attributed to a scientist, describing himself

Quick quiz #53

1 On 30 May 1971, NASA's Mariner 9 probe was launched. Where is it now?

2 Native to Brazil's north-east coast, *Callithrix jacchus* is an example of what sort of primitive monkey with a small brain, claws rather than toenails and no wisdom teeth?

3 "Be less curious about people and more curious about ideas." Which radiochemist said this?

4 Bikini Atoll, the site of 23 US atom bomb tests between 1946 and 1958, belongs to which country?

5 Caused by a mutation in a gene that makes the connective protein fibrillin, what human genetic disorder characteristically results in very long arms, legs, fingers and toes?

Answers on page 54

Quick Crossword #58

Answers

ACROSS 1 Blue-footed booby, **9** Marram, **10** Duck test, **11** Bit decay, **14** Geller, **17** Alpha Centauri, **20** Methylene blue, **23** El Nino, **25** Isostasy, **28** Edgeways, **29** Leonid, **30** Ducted propeller

DOWN 2 Lean In, **3** Eared, **4** Ohmic, **5** Today, **6** Decagon, **7** Octal, **8** Ytterbium, **12** Empty, **13** Alate, **15** Louse, **16** I Am Legend, **17** Actin, **18** Evens, **19** Talus, **21** Leopard, **22** C spine, **24** Inert, **25** InSAR, **26** Oxlip, **27** Troll

Our crosswords are now solvable online
newscientist.com/crosswords

The back pages

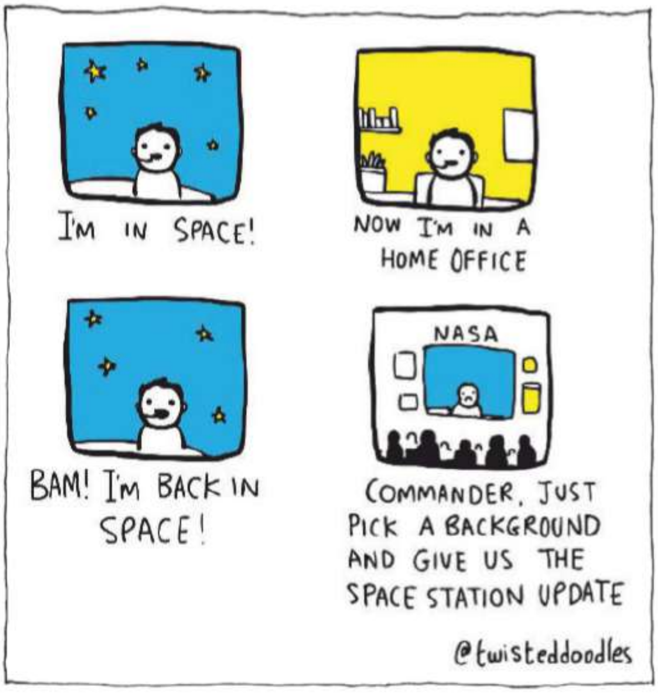
Tom Gauld

for New Scientist

DAMMIT! EVEN PROFESSOR WILSON'S FAILURES ARE MORE IMPRESSIVE THAN MINE.

Twisteddoodles

for New Scientist


I'M IN SPACE!
NOW I'M IN A HOME OFFICE
BAM! I'M BACK IN SPACE!
NASA
COMMANDER, JUST PICK A BACKGROUND AND GIVE US THE SPACE STATION UPDATE
@twisteddoodles

Quick quiz #53

Answers

1 It is still orbiting Mars. The probe completed its mission mapping the planet's surface in 1972, but is projected to burn up in the Martian atmosphere only in 2022

2 Marmoset

3 Marie Curie

4 The Marshall Islands

5 Marfan syndrome

Puzzle

set by Rob Eastaway

#61 Triple jump

"My Auntie Connie just had triplets, three boys!" "Wow, how old is she?" "I dunno, but she's really old." "Do you think the boys' ages will ever catch up to your auntie's? If you add all three together, I mean."

"I'm not sure they'll ever add up to her age exactly – I think it depends on how old she is now."

Assuming they all live to a ripe old age, what are the chances that there will come a date in the future when the ages of the three boys add up exactly to their mother's age? (To be clear: your "age" is how old you were on your last birthday, so it is always a whole number.)

Answer next week

#60 Mexican standoff

Solution

Bumbling has a 78 per cent chance of surviving. The best strategy for each shooter is to take out their strongest rival first, so Good should aim first at Bad, while Bad and Bumbling should aim at Good.

The chance that Bad will get through the first round is only 1 per cent, so we will be close to the right answer if we call that zero. Good only survives if Bad and Bumbling both miss him, 0.33 x 0.66 = 0.22, or a 22 per cent chance. If Good does survive, he is almost certain to kill Bumbling in the second round.

Therefore the chance that Bumbling will survive is 100 – 22 = 78 per cent. The 1 per cent chance of Good missing Bad slightly lowers Bumbling's chances of survival.

JOSIE FORD

Got a story for Feedback?

Send it to feedback@newscientist.com or
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Consideration of items sent in the post will be delayed

Unsolvable puzzle (9)

Our thanks to Richard Weeks for his email enquiring about the puzzles section of the *New Scientist* website. "I'm glad to see you say 'Our crosswords are now solvable online'," says Richard. "To level the playing field, could you please offer that guarantee for the print versions, too?"

Euphemismatism

Some weeks ago, Feedback hitched up the reader engagement wagon and paraded through the streets of this column asking for your best examples of scientific euphemism. Many thanks to those of you who replied, often with unprintable specimens. Among a particularly strong showing we are deeply grateful to Scott McNeil for reminding us of the phrase "rapid unscheduled disassembly", variations of which have been used for decades by rocketry pioneers to describe a hazard of the job. As Scott puts it: "So much simpler to say 'the rocket blew up'."

Time after time

Time flies like an arrow, the saying goes, while fruit flies like a banana. Well, sometimes time flies in odd ways, too.

For Exhibit A, we turn to the *Financial Times*, which reports that the Public Health Department of the state of Georgia has been misleading in its presentation of covid-19 related statistics. The offending item is a graph showing a slow decline in case counts over time, with a y-axis running from 0 to 150 and an x-axis spanning from 28 April to 9 May. So far, so conventional. The weirdness starts when you move along the x-axis and encounter, in order, 28 April, 27 April, 29 April, 1 May, 30 April, 4 May, 6 May, 5 May, 2 May, 7 May – and then, to show you just can't keep a good month down, 26 April – followed by 3 May, 8 May and 9 May.

Regular readers of this magazine will be all too familiar with unusual theories regarding the flow of time. Some physicists say that its passage is dictated by the direction of entropy; others assert that it is governed by the pull of cosmic inflation. But until now, we at Feedback had never come across a model yoking time's flow to the public relations needs of the government of Georgia.

Taking the pi

If you can't do something efficiently, Feedback always says, then do it inefficiently – but with style. That's why we doff our hats (in a roundabout fashion involving two crocodile clips and a handstand) to MIT postdoc Carl-Johan Haster, who has devised what must be the least practical and most costly method yet known for calculating pi.

Pi, as every schoolchild once knew but has forgotten since the start of home-schooling, is a mathematical constant of infinite digits often approximated as 3.14 in order to save paper. It can be calculated in many ingenious ways, with its value known to well past the 50 trillionth digit.

In a recent paper uploaded to the preprint website arXiv, Haster attempted to gild the lily. As a cosmologist on the LIGO/VIRGO collaboration, he had access to data from three incredibly precise interferometers hunting for gravitational waves in the cosmos. By doing a little light-fingered analysis, he could plead ignorance of the value of pi and ask the universe to tell him what it was.

The answer, he revealed, was 3.115 (give or take about 0.06). In Feedback's view, using multibillion-dollar apparatus to produce an answer that could be bettered by a freehand drawing of a circle is inefficiency of such monstrously stylish proportions that we stand in awe.

Amusical intelligence

Switching from stylish inefficiency to unstylishness proper for a moment, the Eurovision song contest is a staple of Feedback's springtime television schedule. This year, alas, the pleasure of a 4-hour exercise in the douze times table was denied us by the global pandemic. But, you will be pleased to hear, that didn't stop us from enjoying some classic Europop.

To coincide with the dates that the music festival was scheduled to be held in Rotterdam, a Dutch broadcaster ran a contest for the best AI-produced song. Well, given that it's Eurovision, "best" might not be the proper adjective. We suppose that Eurovisioniest would be more appropriate. The winning entry, produced by Australian team Uncanny Valley, is a classic of the genre. Called *Alcohol You*, lyrics include "If this is just a dream / Don't wake me in between / I mean it / You lied so many times / But right between the lines / I read it".

Oh hang on – apologies, that was actually Romania's 2020 entry to Eurovision itself. The real AI masterpiece, called *Beautiful the World*, runs: "dreams still live on the wings of happiness". Much less embarrassing.

Name game

Our electronic larder cupboards are overflowing once again with the self-raising flour of your nominative determinism submissions. Feedback is overjoyed to learn of the existence of architect and urban visionary Carolyn Steel, Radio 4 food journalist Dan Saladino and London-based estate agent Lucy Roome. A special mention also goes to Gwynne Shotwell, the president of successful rocket-launching company Space X. ▮

Written by Gilead Amit

Falling awake

Why does falling in dreams happen? You can be drifting off to sleep and then the feeling that you are falling suddenly brings you back to reality. Do other people experience this?

Madeleine Walmsley
Surrey, UK

Over the past few years, I have experienced "sleep falling", and subsequently waking up abruptly, on several occasions. Having explored sleep science as part of my undergraduate degree, as well as finding that many others also "fall" in their sleep, it appears that you and I are not alone or weird in experiencing this.

The feeling is triggered by an involuntary muscle movement called a hypnic jerk that occurs when the body is in the transitional stage between wakefulness and light sleep, known as the hypnagogic state.

When the body enters a state of deep relaxation in preparation for sleep, this sensation can be misinterpreted by the brain as the body falling and therefore being in danger. So the hypnic jerk knocks you back into full consciousness. One proposed explanation for the link between "falling" and experiencing a hypnic jerk in the hypnagogic state is that it is a reflex that improved the chances of survival for our ancestors.

Experiencing hypnic jerks isn't considered to be abnormal or a cause for concern, but it can be exacerbated by the consumption of stimulants as well as by stress. This is why people might experience this strange but harmless sensation at particularly stressful points in their life.

Steve Jacques
Head of anatomy,
Leicester Medical School, UK

I get asked this one quite a bit when I'm teaching neuroscience to medical students. My hypothesis is that it is related to the shutting down of the sensory system as we go through the stages of sleep.

While awake, we are normally aware of the effect of gravity. For example, sitting writing this answer, I am conscious of the pressure of the chair on my bottom, as well as the fact that I can see that objects are orientated correctly along an up-down axis. Furthermore, my inner ear uses gravity to provide constant input about the position of my head.

While falling asleep, a crucial sensory relay station deep in the brain known as the thalamus becomes inhibited. The thalamus is the pathway through which sensations become conscious. If the brain doesn't receive information on the direction gravity is acting, it may conclude that there must be no force pushing back against the body from the floor (or our bed). This is consistent with weightlessness or free fall.

Matt Chamings
Barnstaple, Devon, UK

One reason why the sensation of falling causes us to wake suddenly might be because our distant ancestors lived in trees. Falling out of a tree is a serious health risk and falling asleep is a critical time when it is more likely to occur, as the body relaxes and shifts position. A defence mechanism that wakes the sleeper when this begins to happen would be a distinct survival trait that could be passed on to future generations. Even though we no longer sleep in trees, the mechanism might still be at work in the form of dreams about falling.

Vittoria Dessi
Surmulins, Switzerland

Whatever the cause, the phenomenon is certainly widespread. The ancient Greeks believed that Hades's army of *oneiroi*, Greek for dream demons, were responsible for delivering both visions and nightmares. They liked to play tricks on mortals by making them believe they were falling during dreams.

ROBOR DESTRANI/GETTY IMAGES

Why do some hairs only reach a set length but others keep growing?

This week's new questions

So much stuff **Just how much stuff is there? Can we estimate the quantity of matter in the observable universe?** ***Terry Day****, by email*

So long **Why do some hairs, such in the eyebrows, only reach a certain length, while the hair on your head continually grows longer?** ***Michael Assuras****, London, Ontario, Canada*

Ant funeral

I left an empty plastic laundry basket on the lawn. Later, ants dropped dead companions into it. Where do ants bury their dead?

Mike Follows
Sutton Coldfield, West Midlands, UK

This behaviour is called necrophoresis. It is common among social insects like bees, termites and ants, which need to remove corpses to prevent the spread of pathogens.

Ant colonies have specialised undertakers for the task. They usually carry their dead to a sort of graveyard or take them to a dedicated tomb within the nest. Some ants bury their dead. This strategy is also adopted by termites forming a new colony when they can't afford the luxury of corpse carriers.

Like other insects, the corpse carriers among the common red ant (*Myrmica rubra*) aren't issued with personal protective equipment. They cannot even wash their hands. However, they do practise a form of social distancing in order to limit cross-contamination by staying outside the nest most of the time or congregating near the entrance when resting inside.

This cooperative behaviour goes a step further with the Matabele ant (*Megaponera analis*). These ants send out raiding parties to attack colonies of termites on which they prey. Ants that lose only one or two limbs in an attack are evacuated back to their nest where their injuries are tended to until they can literally get up to speed again, adapting their locomotion, ready for the next foray. ▮

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Clare Wilson

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